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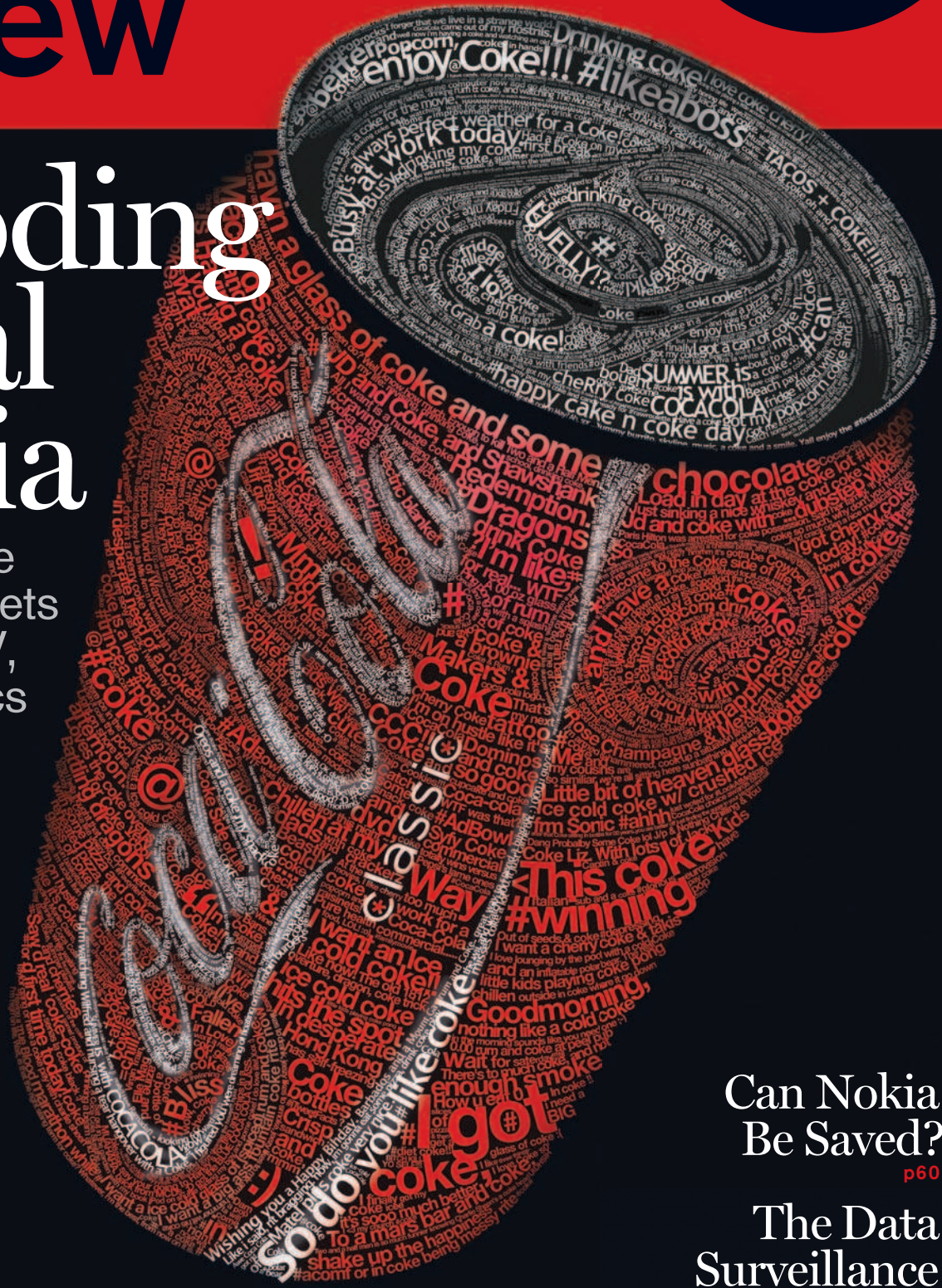

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December 2011
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COVER
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PLUGGED-IN REVOLUTIONS

As someone who has spent the past year interviewing youth organizers in the Arab world about their use of new media, I was heartened by the role of on-the-ground reporting in your Arab Spring coverage ("Streetbook," September/October 2011). What it omitted, however, was the strikingly different role that social media play after momentous political uprisings. Before an uprising, new technologies provide public spheres in repressive political environments, allowing more like-minded citizens to connect. They also accelerate crowd formation. Yet these benefits run the risk of turning into liabilities after the crowd has formed. When structures for mobilization lack a single leader, it is more difficult to come to consensus about next steps. And the more quickly a crowd gathers, the less likely it is to evolve into a sustained organization after it disperses. Egypt's most well-known youth movement, April 6th, is currently grappling with all of these challenges. As I discovered through conversations with its leadership, one Facebook page is no longer sufficient for it to engage with the much broader audience that it must now reach.

Susannah Vila
New York

September/October 2011

As one of the earliest entrants to the Irish blogosphere in 2002, I found powerful resonances in "Streetbook" with our experiences in post-conflict Northern Ireland. John Pollock faces down cyber critics by showing that social media did not make these revolutions but, rather, enabled citizens to connect. But what role might these technologies play post-conflict? Our conflict came to an official end in August 1994, just as the Web was gaining critical mass. If the making of a revolution is drama, punctuated with tragedies too numerous to count, making peace is long-form prose requiring iterations of conversation between people who profoundly disagree about almost everything. For my part, I began the independent politics website Slugger O'Toole as an attempt to explain the complexities of Northern Ireland over a long period of time. Any successful rebuilding of an Arab *demos* must likewise start with modest aims. "Streetbook" tells us that the new digital tools will not be about building virtual ghettos but about engaging people who are trying to solve problems obscured by social oppression and conflict. And it requires commitment to the long haul.

Mick Fealty
Belfast, Northern Ireland

VIRTUAL POSSESSIONS

Why not look at the cloud as a giant video rental service or public library rather than something that will cause us to lose our rights ("A Cloud over Ownership," September/October 2011)? People have borrowed books for eons without feeling the need to "possess" them. I don't need to own copies of most of the media I enjoy. I read a book once and then must find somewhere to put it. I watch a rented movie and am happy to return it. I disagree that putting things in the cloud makes us more likely to lose them. It's extraordinarily easy to make copies of digital media and have them on multiple hard drives and servers or in cloud storage, making the loss of any one copy irrelevant. Backing up digital copies is surely far easier than protecting, cataloguing, insuring, and carting around a thousand pounds of physical books and discs.

Eric Peltzer
Altadena, California

There are a number of reasons why owning something can be better than renting it. For instance, I don't care if HarperCollins goes out of business: I bought the book, it's on my shelf, and I can refer to it whenever I want. The nice thing about owning a book or movie is that if you're strapped for cash, you can still go back to it. With rented content, it is quite possible to lose access to it. The point of ownership is to have unlimited and unrestricted access to a thing.

Jerome Meyers
(jeromeyers)

CAPACITY FOR CATASTROPHE

I found the July/August 2011 issue both encouraging and maddening. "The Problem with Waiting for Catastrophes" and the Q&A with Nicholas Stern nicely make the point that the real issue with climate change is one of good old-fashioned risk management. Yet despite your thoughtful analysis, the Stern interviewer concludes his piece by asking, about the prospect of investing 1 percent of GDP to forestall ecosystem meltdown, "Can we afford it?" In a country that thinks nothing of spending roughly the same amount on consumer electronics, it is nothing less than immoral to even acknowledge that as a legitimate question.

Michael Hogan
Sunapee, New Hampshire

Correction: David Hockney's collages *Pearblossom Hwy.* and *Luncheon at the British Embassy, Tokyo, Feb. 16, 1983* were made with Kodak film, not Polaroid ("The Mind's Eye," September/October).

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Steve's Way

Emulate the methods and values of Apple's late cofounder.

What can we learn from the life and legacy of Steve Jobs, the cofounder, chief executive, and tutelary genius of Apple, who died in October?

More than anyone else, Jobs shaped the machines of the digital revolution and, with those machines, the texture of modernity. He was responsible for six creations of unrivaled influence—successively, the Apple II, the Macintosh, the movie studio Pixar, the iPod, the iPhone, and the iPad—and they all bear the stamp of his methods and values. The products he oversaw were simple, elegant, and genuinely novel.

How did he do it? In a paradox that has been endlessly worried over, Jobs's preoccupation with delighting consumers was accompanied by confidence that there was no point in asking what they wanted. A 1989 interview in *Inc.* magazine contains the best account of his method. He hedged that his process was "hard to explain," but he offered this: "Customers can't anticipate what the technology can do. They won't ask for things that they think are impossible." But, he continued, "it takes a long time to pull out of customers what they really want, and it takes a long time to pull out of technology what it can really give."

Jobs elaborated: "Sometimes the technology just doesn't want to show you what it can do. You have to keep pushing on it and asking the engineers over and over again to explain why we can't do this or that—until you truly understand it. A lot of times, something you ask for will add too much cost to the final product. Then an engineer might say casually, 'Well, it's too bad you want A, which costs $1,000, instead of B, which is kind of related to A. Because I can do B for just 50 cents.' And B is just as good as A. It takes time to work through that process—to find breakthroughs but not wind up with a computer no one can afford."

In his obituaries, Jobs was called a visionary. The word is justified: he had visions, and he persuaded cofounders, investors, employees, and, finally, customers to share them. Yet the word "visionary" implies mysterious powers, and as the *Inc.* interview suggests, Jobs's method wasn't magic. But the details were laborious. He was not an engineer. He combined and refined borrowed ideas (from Xerox PARC most famously, but also from typesetters, industrial designers, and the counterculture). He ignored vulgar consensus, took risks, and killed unsatisfactory projects. He demanded excellence; anything that was substandard, hurried, cluttered, or dumb pained him, and he rejected it. He concerned himself with the smallest details of products, insisting, for example, that his engineers redesign the motherboard of the Mac, which almost no one would ever see, because he found its initial layout aesthetically displeasing. He hired the best designers and engineers, and by persuasion and bullying, he inspired them to build his insanely great machines.

Apple (and by extension Jobs) existed, he always said, at the intersection of the liberal arts and technology. He was an artist whose medium of expression was computing. He wanted to excite passionate fandom from his customers, because he was himself technology's biggest fan. And like all real artists, he didn't create his artifacts to get rich. He did it for the absorbing love of his craft.

In a justly famous speech at the 2005 Stanford University commencement, Jobs spoke about the patterns in life, about the clarifying power of knowing we will die, and about getting fired from Apple in 1985.

He said, "I was a very public failure, and I even thought about running away from the Valley. But something slowly began to dawn on me—I still loved what I did. The turn of events at Apple had not changed that one bit. I had been rejected, but I was still in love. And so I decided to start over."

Jobs insisted that being fired was the best thing that could have happened to him: "The heaviness of being successful was replaced by the lightness of being a beginner again ... It freed me to enter one of the most creative periods of my life." During the next five years, he founded NeXT and Pixar and met his wife. NeXT led to his return to Apple, and he saw the technology he created at NeXT at the heart of the Macintosh operating system.

Jobs concluded: "I'm pretty sure none of this would have happened if I hadn't been fired from Apple ... I'm convinced that the only thing that kept me going was that I loved what I did. You've got to find what you love ... Your work is going to fill a large part of your life, and the only way to be truly satisfied is to do what you believe is great work. And the only way to do great work is to love what you do."

Steve Jobs was an artist and perfectionist. Would that all of us followed his example.

—Jason Pontin

MARK OSTOW

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ENERGY

Dirty Distraction

Controversy over a proposed oil pipeline from Alberta to Texas is sidetracking us from bigger issues, says David Keith.

The U.S. environmental movement has devoted immense effort and political capital to blocking Keystone XL, the pipeline that would bring bitumen from Canadian oil sands to Gulf Coast refineries. James Hansen, the most visible climate scientist to turn anti-carbon campaigner, declared it "game over" for climate change if the pipeline is approved. Yet Keystone is a far from obvious focus for the limited campaign resources available to protect our climate.

Oil-sands fuels emit about 10 to 20 percent more carbon than conventional oil over their life cycle. Suppose Keystone is blocked, or suppose that technical fixes (*see "Alberta's Oil Sands Heat Up," p. 52*) eliminated that extra carbon. Neither outcome would make a big dent in emissions. The root of the climate threat posed by fuels is the carbon emitted when they are burned for transportation. Emissions from vehicles account for more than three-quarters of the life-cycle emissions of petroleum fuels. To solve the problem, we must decouple transportation from petroleum.

Moreover, the oil market is adaptable, so if Keystone is blocked, Canadian bitumen will still find its way to world markets, perhaps by a Pacific route, leaving emissions essentially unchanged.

For all that, there is a sound strategic reason for environmental groups to try to kill oil-sands development. Without constraints, the production of such unconventional hydrocarbon fuels will increase quickly in the coming decades as conventional supplies shrink. This will depress oil prices, meaning that efficiency improvements and alternatives such as electric vehicles will continue to have trouble competing. The oil-sands boom is the biggest unconventional-oil project yet, and Keystone is a centerpiece of that boom.

That's not what you'll hear campaigners say about Keystone, though. Tactics and strategy get confused in the heat of battle, and many of the public arguments against the pipeline are spurious. The threat of pipe leakage, to cite a recently hyped example, is minuscule compared with the environmental risks posed by other new developments in energy, from shale gas to large-scale corn ethanol.

I hope the Keystone permit is denied, because the strategic case for blocking huge capital investments in unconventional fuels is compelling. Yet I worry that the environmental movement has overinvested in a battle it seems unlikely to win—one whose tactics distract attention from the hard choices needed to decarbonize transportation and accelerate energy innovation.

DAVID KEITH IS A PROFESSOR OF PUBLIC POLICY AND APPLIED PHYSICS AT HARVARD UNIVERSITY AND PRESIDENT OF CARBON ENGINEERING, A STARTUP DEVELOPING CARBON-CAPTURE TECHNOLOGY.

WEB

Social Intelligence

Analyzing what people do online provides a way to peer into society's collective mind, says Bernardo Huberman.

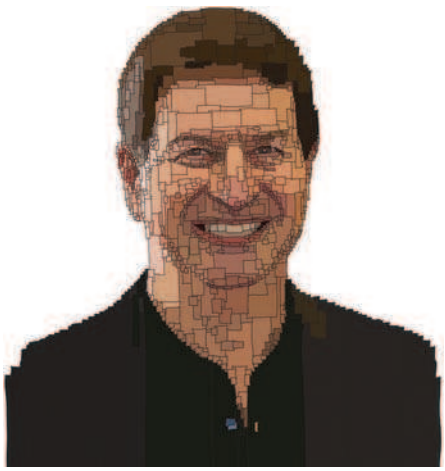
Social media have made information so ubiquitous as to be almost devoid of monetary value. What is scarce now—and therefore valuable—is the user's attention, which explains the intense efforts made to obtain it through focused advertising, short videos within news portals, and, most disheartening, spam.

Understanding how people allocate their attention, as well as steering it to specific content, has tremendous value. In the case of social media, harnessing the enormous and highly variable flow of information that propagates through large user networks can make it possible to predict specific outcomes *(see "A Social-Media Decoder," p. 44)*.

My research group recently showed that Twitter messages can be used to accurately predict box-office revenues for movies about to open in theaters across the country. The basic intuition was simple: the greater the rate at which people discuss a forthcoming movie, the more likely it is to have a large audience on opening night. Studying how feelings about a movie appear on the social network and propagate through it after opening weekend increased the accuracy of forecasts as time went on. Among other advantages, such knowledge might be used to swiftly shift advertising budgets from one movie or product to another.

This type of analysis has a wide range of potential uses. Although we focused on movies because it gave us a good way to verify our predictions, the technique can be applied to all sorts of social-media chatter, from academic discussions of technology to public debate about future products and trends.

NICK REDDYHOFF



But predicting the future, however interesting, is only one potential benefit of knowing how attention is allocated within social media. Large groups of interacting people constitute a collective intelligence that can also be harnessed for myriad purposes. Think of what institutions and enterprises can and will do as social computing that taps into this collective intelligence becomes an integral part of their existence. It will give them a way to pare down the vast number of choices that companies and individuals now face. Organizations ranging from governments to charities will gain new insights into the collective intelligence that enable them to evaluate possibilities and learn of emerging trends. In business, understanding how product rankings and opinions work, and how to best exploit them, will grow in importance as ever greater quantities of data are created online every day.

Making it possible to exploit this wisdom will require efficient ways to filter, extract, and rank insights from social data. Such methods are being developed in my own research group, which is already demonstrating the power of analyzing collective intelligence through social media. Tools will also appear that connect individuals with the workings of the collective mind, creating a new source of information that will help determine our choices and ideas about what to do and how to act.

BERNARDO HUBERMAN IS THE DIRECTOR OF THE SOCIAL COMPUTING LAB AT HP LABS.

RESEARCH

Reinvention

It's a good thing for innovation that the age of monolithic corporate labs is over, says Henry Chesbrough.

Many of the great research-and-development laboratories of the 20th century have been downsized or broken up. Despite nostalgia for powerhouses like Bell Labs, they are unlikely to return.

Those industrial labs were often supported by de facto monopolies that have since been swept away. With knowledge concentrated in those few large companies, society had to rely on centralized internal research to generate innovation. But useful knowledge is much more widely distributed today, making it infeasible and unwise to hoard vital knowledge in such silos.

Tomorrow's labs will need to follow a different, open approach to innovation if they are to deliver new ideas and technologies. Tapping external expertise and sharing the load of innovation with others allows a company to expand its scope and bring new ideas to market faster.

These labs need to test new business ideas as well as new technologies. Clay Christensen's concept of the "innovator's dilemma" demonstrates how established business models stifle the formation and growth of "disruptive" models and technologies. Nokia (*see "Can This Man Work Magic?" p. 60*) has suffered greatly not because of any failures of its technology, but because its business model in mobile telephony has been overtaken by a new and better one from Apple and Google. A research lab can protect nascent business models and technologies from the corporate immune system that kills off challenges to the core business. Allowing new business models to evolve alongside new technology can be vital to earning a return on R&D.

Steve Jobs's decision to give iPhone app makers 70 percent of the revenue from app sales is an example of a business-model innovation that also boosted technological innovation. Jobs's staff argued that Apple should retain 70 percent itself, since it had made the platform for the apps. But by ignoring this argument, Jobs made the resulting ecosystem of apps far more extensive and profitable, creating a place where app makers innovate so Apple doesn't have to do it all.

A good example of a company that has successfully negotiated the transition from old-style to new-style R&D is IBM. Until 20 years ago, Big Blue invented numerous fundamental technologies and developed them into products sold under its own

brand. Then the company was threatened as competitors attacked on numerous fronts. IBM came close to shattering into several smaller companies, but it survived by opening up its innovation. It used outside tools like Java and Linux, and it offered its own technologies to others for licensing. Opening up its R&D and its business model saved IBM.

The lesson is that the processes of industrial innovation are themselves being innovated. The champions of the future won't be the companies with giant, closed laboratories; they will be those that find the best way to combine outside ideas and technologies with their own. tr

HENRY CHESBROUGH, A PROFESSOR AT THE HAAS SCHOOL OF BUSINESS AT THE UNIVERSITY OF CALIFORNIA, BERKELEY, IS THE AUTHOR OF SEVERAL BOOKS ON OPEN INNOVATION.

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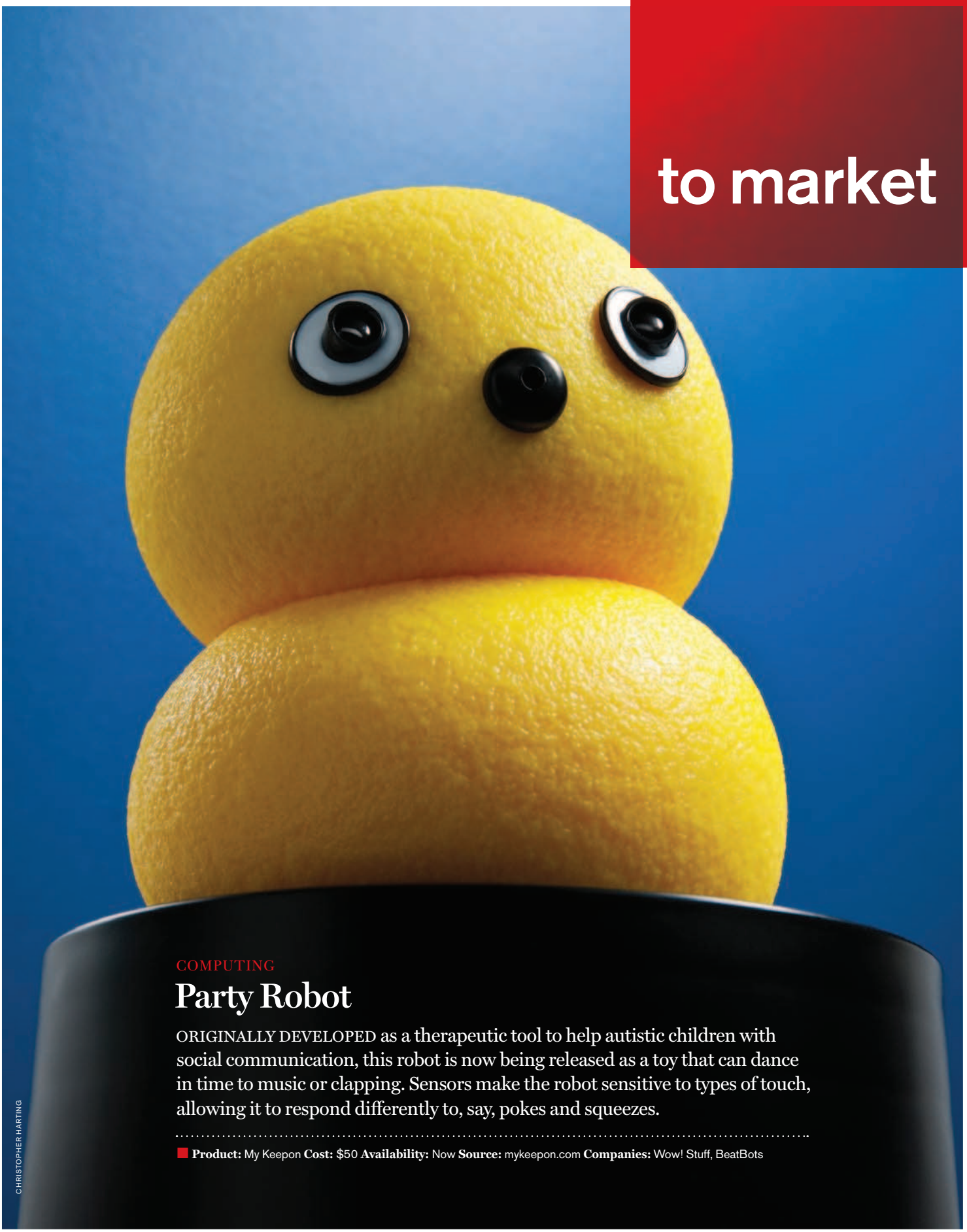

COMPUTING

Party Robot

ORIGINALLY DEVELOPED as a therapeutic tool to help autistic children with social communication, this robot is now being released as a toy that can dance in time to music or clapping. Sensors make the robot sensitive to types of touch, allowing it to respond differently to, say, pokes and squeezes.

Product: My Keepon **Cost:** $50 **Availability:** Now **Source:** mykeepon.com **Companies:** Wow! Stuff, BeatBots

CHRISTOPHER HARTING

ENERGY

Fallout Alert

GAMMA RADIATION can be measured with this solid-state personal detector that uses an iPhone to display, store, and share measurements. Users can choose a detailed display or a simplified readout that indicates whether radiation levels are safe, elevated, or dangerous. The detector can also function without an iPhone as a stand-alone radiation alarm.

Product: RDTX Pro **Cost:** $330 **Availability:** Now **Source:** www.scosche.com **Company:** Scosche

TRANSPORTATION

On-Demand Transit

THE PERSONAL rapid transit (PRT) system at London's Heathrow airport is the first such commercial system in the world. Passengers wishing to travel between the terminal and the parking lot can summon a battery-powered, autonomously driven pod that can hold four people plus their luggage. It takes each pod about five minutes to traverse the 3.8-kilometer distance along a dedicated guideway.

Product: ULTra PRT system **Cost:** N/A **Availability:** Now **Source:** www.ultraprt.com **Companies:** BAA, ULTra PRT

COMPUTING

3-D Surveillance

THESE DIGITAL BINOCULARS offer not only a 20x optical zoom but the ability to capture images in 3-D high-definition video. Essentially composed of two camcorders bundled together, the binoculars can also make 2-D movies and take still photos with a resolution of seven megapixels.

Product: DEV-5 **Cost:** $2,000 **Availability:** Mid-November **Source:** www.sony.com **Company:** Sony

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COMPUTING

Point and Scan

THIS MOUSE doubles as a scanner: it's swiped over a document or picture as needed until a complete image is formed on screen. The multifunctional device eliminates the missed areas and wavy captures that previous handheld scanners were prone to.

Product: LSM-100 **Cost:** $130 **Availability:** Now **Source:** www.lg.com **Company:** LG

COMPUTING

Digital Doodles

THIS SYSTEM for capturing pen strokes doesn't require special paper or a digitizing tablet underneath the page. Instead, the user clips a receiver onto the page, and the location and pressure of the pen are tracked using ultrasonic and infrared technologies. Drawings can later be transferred from the receiver using a USB connection.

Product: Inkling **Cost:** $200 **Availability:** Now **Source:** www.wacom.com **Company:** Wacom

LG (MOUSE); WACOM (PEN)

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COMPUTING

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Product: AudioBulb **Cost:** $300 (for starter kit) **Availability:** Now **Source:** giinii.com **Company:** GiiNii

COMMUNICATIONS

Safer Sound

THESE EARPHONES are equipped with a filter circuit powered by the audio signal itself. This limits average sound levels to a maximum of 85 decibels without attenuating soft sounds or audibly distorting louder sounds.

Product: EP-100 Earphones
Cost: $35 **Availability:** Now
Source: www.dblogic.com
Company: dBLogic

COMPUTING

Portable Protection

MOST CONSUMERS who own an external hard drive balk at buying a second external drive just to back up the data on their first one, so Toshiba has added a cloud-based backup system to its Canvio line of external hard drives. Users can specify folders or certain file types (such as pictures), which are then copied automatically to cloud servers.

Product: Canvio 3.0 Portable Hard Drive **Cost:** $90 to $140 **Availability:** Now
Source: www.toshiba.com **Companies:** Toshiba, NTI

AUDIOBULB (LIGHTBULB): CHRISTOPHER HARTING (EARPHONES); TOSHIBA (HARD DRIVE)

SINGAPORE:
Asia's Innovation Capital

Singapore's investments in research and innovation—and the returns on those investments—have continued to rise dramatically in recent years. After building up a spectrum of deep capabilities in biomedical science and physical science and engineering, the country is moving into multidisciplinary research. Researchers at all levels continue to be attracted here from within Singapore and from around the world to participate in advanced research. Multinational companies are bringing not only manufacturing and services but also their R&D investments to the nation, and new public and corporate R&D labs continue to be set up here. Together with a well-coordinated hospital system and internationally recognized universities, this has created a vibrant R&D and innovation ecosystem in Singapore.

Singapore also offers unparalleled access to the rapidly-growing Asian market, yet it is an English-speaking city. It offers easy collaboration among research institutes, hospitals, universities, and industry; it is an excellent place to test city-based solutions to worldwide challenges that include water management, energy, transportation, and health care. Singapore is a living laboratory whose results can be translated into opportunities and solutions for cities around the world.

All these factors demonstrate that Singapore is well on the way to establishing itself as Asia's Innovation Capital, and the research and solutions developed in Singapore will resonate around Asia and potentially around the world.

As Singapore celebrates 20 years of science and technology planning and development this year, we take a look at how a small country with five million people and a land area of just 712 square kilometers could achieve so much, so quickly.

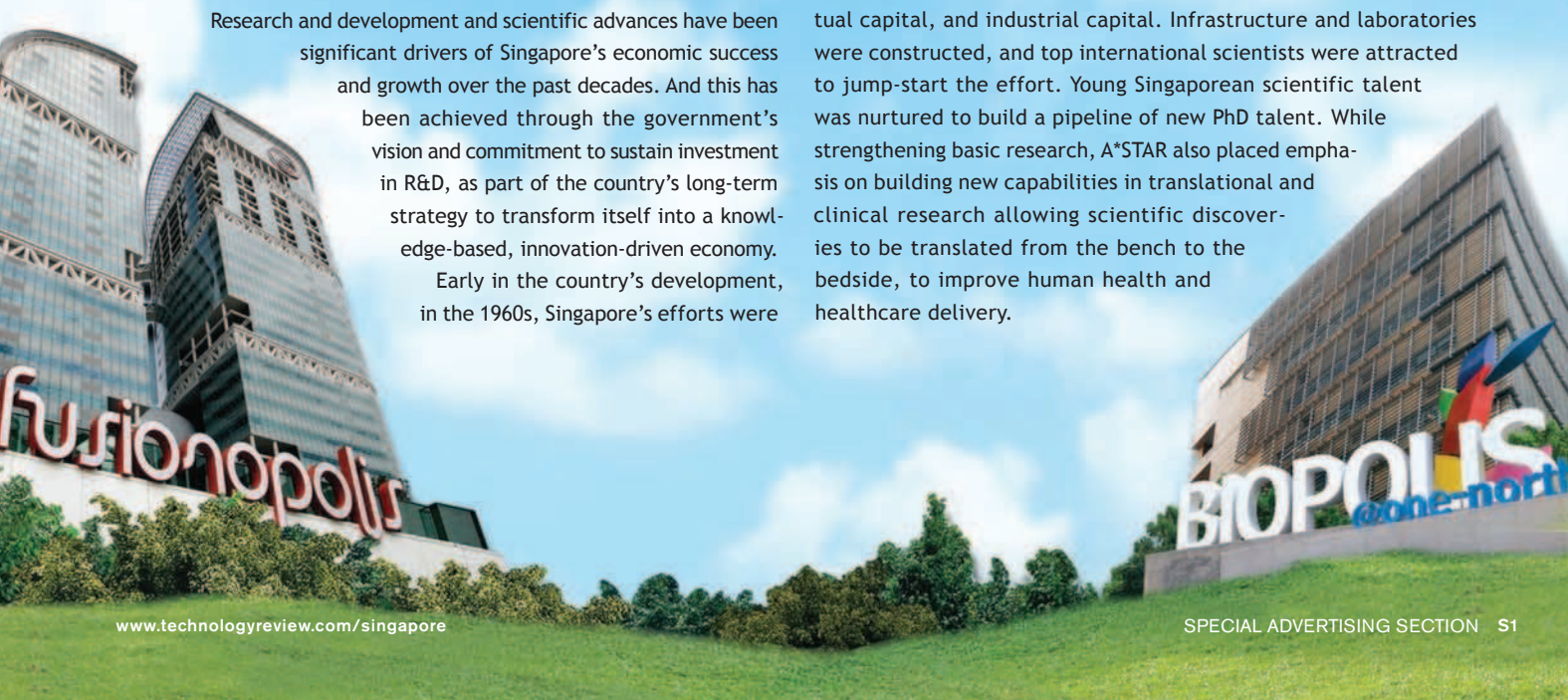
FOCUS ON RESEARCH AND INNOVATION

Research and development and scientific advances have been significant drivers of Singapore's economic success and growth over the past decades. And this has been achieved through the government's vision and commitment to sustain investment in R&D, as part of the country's long-term strategy to transform itself into a knowledge-based, innovation-driven economy.

Early in the country's development, in the 1960s, Singapore's efforts were directed at attracting foreign investment to create jobs by developing the country into a manufacturing base for labor-intensive goods. By the 1970s, Singapore's workforce had become better educated, and the country began attracting skills-intensive, high-value-added industries such as electronics, data storage, and petrochemicals. But globalization, and increasing economic competition and uncertainties, spurred the country to look for new pillars of economic growth to differentiate itself from its competitors in the region and the world. Singapore decided that it must promote strong intellectual-capital creation as a basis for developing knowledge-intensive industries and generating high-value-added jobs.

The first five-year science and technology plan was launched in 1991, which marked the beginning of Singapore's sustained effort at promoting R&D to transform its economy, with an initial commitment of S$2 billion (1.6 billion US$). The government's scientific and technology arm, at that time called the National Science and Technology Board (later renamed A*STAR—Agency for Science, Technology and Research—in 2002), established research institutes to develop core R&D capabilities in physical science and engineering. The investment subsequently doubled to S$4 billion (3.2 billion US$) for a second five-year science and technology plan. Over the 1990s, capital- and technology-intensive industries were anchored here. In the next decade, government investments in R&D continued to rise [S$6 billion (5 billion US$), for 2001-2005; and then S$13.9 billion (11.6 billion US$), for 2006-2010].

Biomedical sciences has been identified as a new growth area in Singapore since 2000, as A*STAR laid out strategic initiatives to develop Singapore into a world biomedical hub. Key building blocks were quickly put in place to establish core biomedical science capabilities through the development of human capital, intellectual capital, and industrial capital. Infrastructure and laboratories were constructed, and top international scientists were attracted to jump-start the effort. Young Singaporean scientific talent was nurtured to build a pipeline of new PhD talent. While strengthening basic research, A*STAR also placed emphasis on building new capabilities in translational and clinical research allowing scientific discoveries to be translated from the bench to the bedside, to improve human health and healthcare delivery.



Today, more than 100 biomedical science companies have operations in Singapore, with more than half establishing research facilities, adding their own intellectual capital to that of the country's public research institutions. This has created a wealth of new jobs in the biomedical science sector, doubling the number of jobs by 2009 from fewer than 6000 in 2000. The investment has paid off and has put Singapore on the world biomedical map.

Over the last two decades, Singapore has developed a strong, integrated R&D ecosystem comprising a plethora of research performers with key capabilities in physical science and engineering and biomedical sciences. Its universities have intensified their research in these areas. A*STAR alone, the lead public agency for science and technology research, has 20 research entities that are fully engaged in world-class R&D, covering areas such as microelectronics, data storage, materials, high performance computing, genomics, biologics, stem cells, immunology, and others. Of the 2,600 research scientists and engineers from A*STAR's science and engineering and biomedical research institutes, more than 50% come from 60 countries around the world. Singapore has indeed built up a vibrant and diverse community of local and international senior and junior researchers and scientists, making the country truly an international R&D hub.

BIOPOLIS AND FUSIONOPOLIS: TWIN HUBS FOR SCIENTIFIC R&D

A*STAR built two major research hubs in proximity to one another to facilitate easy idea transfer and collaboration among different scientific disciplines and talents, creating opportunities for researchers to integrate their capabilities as part of a vibrant community.

Biopolis, a major biomedical hub, has research centers and corporate laboratories (including those of Novartis, Fujitsu, and GlaxoSmithKline) that focus on basic science, translational medical research, drug discovery, and medical technologies. Fusionopolis, the science and engineering powerhouse, hosts research centers that tackle global challenges such as energy, transportation, urbanization, and aging populations, and innovate with novel materials, computers, and electronics. These centers are located close to local universities and hospitals.

Researchers can easily stroll from Biopolis to Fusionopolis to share ideas and develop multifaceted solutions that build on the strength of a wide variety of institutions. This provides unique strength to Singapore's research environment, as opposed to developing ideas within the confines of one individual discipline.

COLLABORATION FOR MULTIDISCIPLINARY RESEARCH

With its spectrum of capabilities and approach to collaborative innovation, Singapore is well positioned to effectively conduct multidisciplinary research, which many other research hubs have hoped to do.

This approach has seen some success. One such example is the development of the fastest and least expensive DNA sequencing device, based on pyrosequencing chemistry and high-resolution image sensing, which leverages two vastly different sorts of expertise: DNA sequencing from A*STAR's Biomedical Research Council (BMRC) researchers, and image sensor development and microfluidics from A*STAR's Science and Engineering Research Council (SERC) researchers.

Multidisciplinary research is also focused on developing solutions for the technology of today and the future. As Raj Thampuran, executive director of A*STAR's SERC, says, "Clearly the world is going to be driven strongly by data. We are consumed by the need to understand how all this data is going to be stored. And then the question is: What are the technologies that will be the movers in this field?"

To help solve this problem, the Institute of Microelectronics (IME) and the Data Storage Institute (DSI) are pairing up to develop new

Investing in Talent for the Future

A key underpinning of Singapore's R&D strategy is talent. One of A*STAR's goals has been to attract top researchers and scientists while nurturing emerging scientists, who will spearhead the country's innovations and discoveries.

Some international luminaries working here include David Lane, who was jointly responsible for discovering the tumor-suppressing gene, and Alan Colman, one of the creators of the cloned sheep, Dolly. The executive director of A*STAR's Data Storage Institute (DSI), Pantelis Alexopoulos, spent more than 30 years in industry, putting in stints at international powerhouses such as IBM, Maxtor, Seagate, and Hitachi Global Storage Technologies. He is now overseeing collaborations among DSI, local universities, and industry partners.

Besides attracting eminent scientists, A*STAR focuses on developing young research talent. The best and brightest young Singaporeans are enabled to pursue undergraduate and graduate scientific training in top universities, locally and around the world. Many can be found in major US universities. According to Stanford University president John Hennessy, Singapore has the highest percentage of PhD students per capita at Stanford, almost all of them on A*STAR scholarships.

These scholarships include the National Science Scholarship, which makes it possible for the most talented young Singaporeans to study from undergraduate work all the way to the PhD level at overseas universities. The A*STAR Graduate Scholarship gives the best local graduates from the National University of Singapore and the Nanyang Technological University a chance to complete PhD training at nine prestigious universities locally and abroad, through a "sandwich" PhD program. In addition, A*STAR offers the A*STAR International Fellowship to new PhDs from local universities who are interested in a life of research. This gives them the chance to undertake fully funded two-year postdoctoral training programs at overseas universities and private-sector labs of their choice. This training will expand their research experience, deepen their domain knowledge, and enable them to establish networks and links with international researchers.

technologies for computer data storage. In one such research project, the centers are developing thin hard drives to serve the exponential growth (and thus hard-drive needs) of the tablet industry, which is poised to become the computer technology of the future. A new hybrid thin drive could significantly reduce a tablet's power consumption. Local researchers are developing a prototype and a pilot line, and the solutions will be licensed to industry partners.

Another area of research that will benefit greatly from multidisciplinary research is biointerphase science research, which requires the knowledge and expertise of researchers from disciplines as diverse as biology, physics, chemistry and materials science.

With the space and platforms readily available for scientists to explore multidisciplinary research, it follows that new knowledge will be created, innovative scientific advances made, and ingenious technologies developed to deal with the many challenges prevalent today and in the future.

This ability to integrate diverse research capabilities and achieve maximum impact is one of A*STAR's key value propositions.

SINGAPORE'S SUCCESS

Singapore's success is reflected in the international acclaim that it has rapidly received for the country's intellectual capital. In just one decade, the number of scientists leapt from 14,500 to 26,600, an increase of more than 80 percent. As of 2007, Singapore had published the highest number of scientific papers per capita in top international journals, demonstrating high recognition for the country's researchers. According to Nature's Asia-Pacific publication rankings in 2009, Singapore ranked fifth in the region by country for research paper output (among the ranks of top Asian R&D giants Korea and Taiwan), while A*STAR ranked seventh in the institution category. A*STAR researchers publish about 3,200 papers and file about 225 primary patent publications on average every year.

Singapore's gross expenditure on R&D (GERD) was S$7.13 billion (5.9 billion US$) in 2008, about 2.77% of GDP. Overall, GERD grew rapidly, at a compound annual growth rate (CAGR) of 11.2% from 2000 to 2008, an indication of the increasing intensity of R&D activities in Singapore. This significant investment in R&D will continue in order to maintain Singapore's position among R&D-intensive countries that include Finland, Sweden, and Japan. In fact, Singapore aims to raise GERD to 3.5% of GDP by 2015, achieving this goal primarily through growing business R&D activities. It has also announced a S$16.1 billion (12.4 million US$) national budget for R&D for the next five years, to support research, innovation, and enterprise activities.

Already, Singapore has established itself as a preferred location for R&D activities. Roche, GSK, Abbot, HP Labs, Fujitsu, Seiko Instruments, Thales, Gamesa and Nitto Denko are among the companies that have set up dedicated R&D arms in Singapore in recent years.

Among the first few Singaporeans to embark on a PhD grant from A*STAR was Cheok Chit Fang, who began her studies in 2001. In 2006, she began her postdoctoral training under the tutelage of David Lane (A*STAR's chief scientist). Today, Chit Fang leads the IFOM-p53Lab Joint Research Lab, the first international outpost of the Italian FIRC Institute of Molecular Oncology (IFOM).

Another rising researcher who has benefited from A*STAR's scholarship is Joel Yang, who focuses on plasmonics. Yang was granted a scholarship to study for his PhD at MIT. While at MIT, his team developed a single-photon detector that can receive information via low-intensity light, which could in theory provide the tools for real-time data transfer from as far away as Mars. After completing his PhD in electrical engineering, Yang returned to A*STAR as a recipient of a competitive three-year grant. "When I came back, I was very impressed with the researchers here and the resources that are available for equipment," says Yang. At A*STAR's Institute of Materials Research and Engineering (IMRE), his work on plasmnonics could result in much denser data storage for the future of computing and electronics.

(LEFT TO RIGHT) Alan Colman, Cheok Chit Fang, David Lane, Pantelis Alexopoulos, and Joel Yang.

LOOKING TOWARDS THE FUTURE

As global demand shifts towards Asia, more corporate R&D activities are expected to move there too, to be closer to markets and respond better to customers' needs. Singapore is well positioned to take advantage of the opportunities that will arise as a result of this shift. With sustained commitment to research and innovation, coupled with necessary infrastructure and diverse pool of scientific talent and capabilities, Singapore is today a R&D powerhouse that advances world-class research and innovation. Singapore's plans to accelerate collaborative innovation and technology transfer will undoubtedly help the country continue its forward trajectory in medicine, technology, and science.

Says A*STAR's Chairman Lim Chuan Poh, "Research and innovation are now a vital pillar of Singapore's economic strategy for the future." He points out that its dramatic results demonstrate that this investment thus far has proved successful, and that its continuing investment in science, medicine, and technology will strengthen Singapore's position as Asia's Innovation Capital.

Lim Chuan Poh, A*STAR's Chairman

Partnering with Industry

Partnerships with private industry in mission-oriented research have long been a key component of Singapore's strategy, and private R&D investment in Singapore (in both physical facilities and jobs) has grown rapidly alongside public investment.

A*STAR's research institutes actively collaborate with companies by offering their deep R&D capabilities, infrastructure, and multidisciplinary value proposition to innovate new solutions for increasingly complex problems.

A collaborative approach to research is particularly critical in an age where problems are complex such that they need solutions that lie not in a single discipline, but in interfaces between disciplines, and come from multiple sources. An example of industry collaboration is Siemens Water Technologies' partnership with the researchers at A*STAR's Institute for High Performance Computing (IHPC). On multiple occasions they worked together to optimize and redesign water purification systems, as the technology evolved for modeling the flow of water through membranes. "It's very complex, not easy to see, and not always intuitive," says IHPC executive director David Srolovitz. "That's where computational models help. We help them build an intuition base without trial and error, which helps them design in a more intelligent fashion."

It is clear that Singapore is sharpening its focus on collaborative and co-innovation partnerships. The A*STAR-CIMIT (Center for Integration of Medicine and Innovative Technology) collaboration enables the use of select technologies in CIMIT's pipeline for development and implementation in Singapore. So biomedical scientists, clinicians and engineers in Singapore can work with their counterparts in Boston to refine engineering solutions with clinical and market relevance for Singapore and Asia and commercialize them.

To further accelerate private-public industry engagement and partnerships, A*STAR has developed a Master Research Collaboration Agreement (MRCA) to ease the path to research collaboration with major international biotechnology and life sciences companies. The MRCA allows them to sign one overarching legal agreement that covers a wide variety of institutions, including multiple research centers, hospitals, and universities. This innovative agreement allows companies to avoid unnecessary time, energy, and capital spent on developing agreements with each separate institution.

Proctor & Gamble (P&G) signed such a MRCA with all 14 of A*STAR's research institutes, setting the stage for collaboration across technologies in chemicals, bio, smart products, and packaging, as well as process development to aid new product development. P&G is also setting up a Singapore Innovation Center in Biopolis, expected to open in 2013.

In addition, the biomedical giant Roche is creating the Roche-Singapore Translational Medicine Hub; Roche is investing 100 million Swiss francs (108.8 million US$) to collaborate with local scientists and clinicians and conduct research that will lead to drug discovery and development. This is the first such Roche facility in the world.

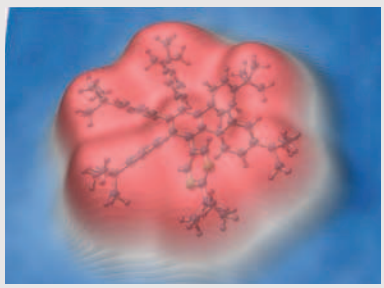
Other leading multinational corporations, such as Genentech, GlaxoSmithKline, and Lonza, have invested about S$2.58 billion (2 billion US$) since 2007 to set up biologics manufacturing plants, in addition to their earlier investments, which will provide jobs for 1300 employees.

Singapore has also created a unique environment for competitors to collaborate on precompetitive R&D. This is made possible through A*STAR's consortia, bringing companies together for collaboration with local research institutes. Such research benefits the companies by allowing them to take advantage of Singapore's top scientists and research facilities to investigate new solutions at the same time.

An example is the Aerospace Program in Singapore, launched by A*STAR in 2007. It brings together 19 aerospace companies from around the world, including Boeing, EADS, Rolls Royce, and Pratt & Whitney, to participate in precompetitive R&D by leveraging A*STAR's scientific know-how and resources. The program is a platform to harness and synergize the strengths of both public and private sectors, to jointly build a long-term technology roadmap, and develop new technologies in strategic areas within the aerospace domain.

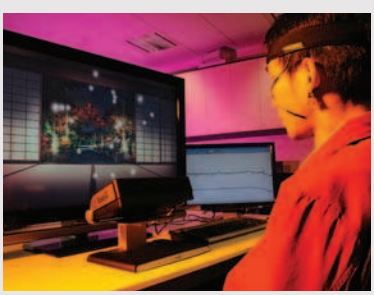
A*STAR: Creating Growth, Enhancing Lives

A Guinness World Record for Singapore: A*STAR IMRE's World's Smallest Working Gears



A*STAR's Institute of Materials Research and Engineering (IMRE) researchers collaborate with France's Centre National de la Recherche Scientifique (CNRS) to develop the world's smallest gears, 100,000 times smaller than the width of a single strand of hair. Viewable only with powerful microscopes, this example of a radical shift in the scientific progress of molecular machines may lead to innovations like pocket-sized supercomputers, miniature energy-harvesting devices, and data computing on atomic-scale electronic circuits.

Brain-Computer Interface Offers Hope for Stroke Rehabilitation

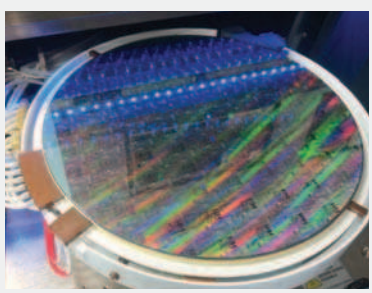


A*STAR's Institute for Infocomm Research (I²R) Brain-Computer Interface (BCI) team, led by Dr. Guan Cuntai, developed jointly with Singapore medical doctors the "Motor Imagery-Based Brain-Computer Interface (BCI) Robotic Rehabilitation for Stroke," which won the International Annual BCI Research Award in 2010. With a BCI, stroke patients can now undergo treatments that nearly rewire their brains, mitigating the debilitating effects of their conditions.

A "Living Laboratory" for New Energy Technologies

Singapore's Experimental Power Grid Centre (EPGC)—the first of its kind in Southeast Asia—is an S$38m ($29.2 million US$) test bed facility that supports and conducts research, development, and demonstration of technologies for intelligent grids, microgrids, and distributed energy resources. Partners that will collaborate with A*STAR at the facility include Rolls Royce and Vestas.

Boosting Next-Generation Wafer-Manufacturing Capability



A*STAR's Institute of Microelectronics (IME) and Institute of High Performance Computing (IHPC) have teamed up with Nanyang Technological University (NTU) and industry partners such as Chartered Semiconductor Manufacturing Ltd, STATS ChipPAC Ltd., and United Test and Assembly Center Ltd., to launch a 3-D-Through-Silicon Via (TSV) consortium to boost next-generation 300mm wafer manufacturing capability. The increased demand for miniaturization and greater functionality in electronic devices means the scaling limit for semiconductor process technology will soon be reached. An approach to circumvent this is through 3-D integrated chips (IC) integration, or the vertical stacking of IC chips or packages, enabled by TSV—a vertical electrical connection that passes completely through a silicon wafer or chip to create 3-D ICs or packages. By allowing this vertical stacking, TSV opens up new possibilities for adding complex and multifunctional features to electronic devices.

Lab-in-a-Cartridge for Fast and Accurate Detection of Cancer and Infectious Disease

The MicroKit, developed by A*STAR's Institute of Bioengineering and Nanotechnology (IBN), allows easy and affordable testing for cancer, avian flu, and other diseases. The automated diagnostic system, which requires a shorter processing time than current tests, takes the form of compact and disposable cartridges, and translates to substantial cost savings. Patients with cancer or infectious diseases stand to benefit from the MicroKit's sensitive and accurate diagnostic capabilities. Non-clinical personnel are now able to conduct mass health screenings at strategic locations like airports to help contain the spread of infectious diseases.

Agency for Science, Technology and Research
SINGAPORE
1991-2011 Creating Growth Enhancing Lives

National University of Singapore:

Delivering High-Impact Research

Founded in 1905 as a small medical school, the National University of Singapore (NUS) has expanded into a world-class research institution, whose research centers and local and national partners enable the university to make its mark in science, technology, and the humanities. In the past five years alone, NUS tripled its research investment, with more than 90 percent of the university's research funded by external grants.

"With state-of-the-art facilities and equipment, the NUS infrastructure enables faculty to engage in research of the highest caliber," says Barry Halliwell, deputy president (research and technology) of NUS. "This helps foster a supportive environment and academic culture, leading to peaks of scientific excellence as well as a high-impact education in Singapore."

Today, NUS remains Singapore's only university with a medical school, and offers an undergraduate medical degree and a graduate school in partnership with Duke University. The university also houses 21 university-level scientific research centers, covering subjects ranging from environmental sustainability to nanomaterials. Since 2007, three national-level research centers have opened on the campus, focusing on quantum technologies, cancer science, and mechanobiology (the study of how mechanical forces affect cells). All together these centers have attracted more than S$300 million (nearly 250 million US$) in government funding.

Researchers in biology and medicine partner with others on campus with engineering expertise to advance biomedical technology. For instance, NUS researchers contributed to the growing use of simulators to train doctors by developing the world's first abdominal simulator, dubbed "Abe the Tummy Dummy." Abe proved particularly useful in 2009, when the outbreak of H1N1 influenza limited physical contact between medical students and patients. This simulator has since been made increasingly more realistic, with silicon skin and lifelike facial features that will allow the dummy to show symptoms of various diseases. The NUS team hopes to soon collaborate with manufacturers to produce it for medical schools and hospitals worldwide.

The caliber of local science at NUS prompted MIT to set up a research center, which is called the Singapore-MIT Alliance for Research and Technology. The Alliance is focused on infectious diseases, environmental sensing and modeling, and healthcare technologies; it is the first such MIT research center to open outside MIT's Cambridge, Massachusetts campus.

"The university is particularly interested in ensuring that its research delivers practical benefits to society," says Halliwell, pointing out that the NUS Center for Remote Imaging, Sensing, and Processing (CRISP) provides satellite remote-sensing capabilities useful to researchers in Singapore and around the globe. In 2004, immediately after the Indian Ocean tsunami on December 26, CRISP images provided the world with its primary source of information on the damage.

To continue to cement its role as a knowledge center with particular relevance to Asia, NUS is building up five integrated research clusters (which will work on subjects that include aging, integrative sustainability solutions, and Asia studies) that will enable university researchers to partner across disciplines and create holistic understandings and solutions potentially applicable in the region. These centers will delve into topics such as education, public health, resource management, and energy and food security. The university retains a global focus as well, and hosts more than 36 thousand students from 100 countries.

NUS research in science, engineering, and medicine remains among the best in the world. According to Thomson Reuters, among its 22 major fields of research, NUS can boast of 18 that rank in the top 1 percent of university departments. These rankings are based on citations of papers published by NUS researchers, especially in the fields of materials science, engineering, chemistry, and pharmacology.

NUS continues to excel, explains Halliwell, because of "government investments, national research strategies, and collaboration with industry." And both its expertise and its contributions to advancing scientific frontiers are expected to keep growing in the future.

Nanyang Technological University:

Developing tomorrow's solutions through technology and science

When Bertil Andersson was tapped to become provost of Singapore's Nanyang Technological University (NTU), one of Singapore's two largest public universities, he was thrilled. Andersson moved to Singapore with experience that included service as president of Linköping University in Sweden; chief executive of the European Science Foundation; and trustee of the Nobel Foundation and chairman of the Nobel Committee for Chemistry.

"I saw a lot of potential in NTU, and today NTU has become one of the youngest and fastest-rising universities, ranked among the top 100 on the Quacquarelli Symonds (QS) World University Rankings [for] 2011," he says.

NTU shot up 16 places in the 2011 QS rankings, to 58th place. With more than 33,000 students in four colleges, NTU's engineering college is the world's largest, and is internationally ranked in the global top five for research output.

As provost, Andersson oversaw a leap in research and innovation investment, and as a result NTU saw dramatically increased research output. In July, 2011, Andersson took over as university president, and he continues to attract and expand investment in research fields as diverse as sustainability, health care, and new media.

"New discoveries are happening at the interface between disciplines," he says. "You cannot be a narrow specialist in today's knowledge society, and much of our research funds are going into collaborations to solve complex, multifaceted problems."

Between 2005 and 2010, NTU won more than S$1 billion (769 million US$) in competitive research funding. Leveraging its strengths in engineering and technology, NTU concentrates its interdisciplinary research efforts primarily in sustainability, health care, and new media.

One of those centers is the Nanyang Environment and Water Research Institute (NEWRI), which capitalizes on Singapore's experience with water treatment. NEWRI focuses on sustainable sources of clean water and environmental solutions and aims to develop new technologies that can be applied worldwide.

NEWRI is only one of many NTU research centers developing solutions for a sustainable future. The university has received more than S$830 million (638.5 million US$) for sustainability research.

As part of that focus on sustainability, NTU attracted microbiology expert Staffan Kjelleberg, joint director of the Centre for Marine Bio-Innovation at Australia's University of New South Wales. Kjelleberg, internationally renowned for his research on adaptive responses of bacteria, signaling between bacteria, and biofilm biology, now heads the new Singapore Centre on Environmental Life Sciences Engineering (SCELSE).

Bertil Andersson gets together with students at the university's main 200-hectare garden campus.

(**CLOCKWISE FROM ABOVE**) Staffan Kjelleberg (middle) with members of SCELSE, Prof Michael Givskov (left) and Prof Yehuda Cohen (right). Scarless robotic stomach surgery pioneered by NTU. Kerry Sieh in his quest to understand natural hazard challenges facing Southeast Asia.

The first goal of SCELSE is to increase knowledge about biofilms—communities of microorganisms—and the role they play in cleaning up pollutants and in treating wastewater. For example, while Singapore has employed technological solutions for water treatment, biofilms can be more efficient and energy smart. Kjelleberg hopes to soon develop methodologies to tease out the answers to questions such as which microbial community can most efficiently mop up a given pollutant.

"There's an enormous diversity [in microbial life]," explains Kjelleberg. For a biofilm to clean water, or any environmental site, "it hangs on the capacity and composition of the microorganisms to do that job. If you understand how that works, you can be more directed to a particular treatment system."

Advances in technology allow the center's researchers to perform rapid genetic analyses on complex biofilm communities, analyses that only a few years ago would have been difficult and expensive. For instance, researchers can perform genomics studies to identify all the genes in a community and understand their different functions. "So suddenly it's gone from [being] a black box, to now being able to [pry open] that black box and understand what microorganisms are there and what they do," says Kjelleberg.

The newly opened center has experts who can perform the necessary gene sequencing and who can apply a systems-biology approach to understanding how diverse biofilm communities are wired, how they respond to their natural or engineered environments, and how they integrate their microscale activities into the desired bioprocesses. Its researchers have already detailed the community of microorganisms in one of Singapore's wastewater treatment plants, says Kjelleberg: "It's a fantastic readout of what's there and the functionality, and we can see transcriptions of every gene that the community expresses."

Biofilms are useful for more than cleaning up industrial water or environmental contamination. Kjelleberg highlights the role of microbial communities in harboring pathogens in our environments and for mediating infectious disease, for instance in the lung tissue of people who suffer from cystic fibrosis. Understanding such communities could allow researchers to address many public health issues more adequately and treat patients more effectively.

In a continuing quest to develop a base of knowledge about its region's environment, NTU set up the Earth Observatory of Singapore (EOS), with Kerry Sieh as its director. Sieh, a professor from the California Institute of Technology, had spearheaded previous discoveries about faults in California and Sumatra that led to long-term forecasting of large-scale earthquakes. EOS has a team of experts who focus on natural hazards endemic to the region: tsunamis, volcanoes, earthquakes, sea level rise, and climate change.

"We want to know where and how big the next tsunami will be, and where the next major volcanic eruption will occur, and how these will affect the region's cities," says Sieh. "And with glaciers melting, will sea level rise swallow up a third of Jakarta?"

He adds that in the year that the center has been open, it has begun monitoring volcanoes in the Philippines and in Indonesia, and its scientists have created a network of GPS stations in Bangladesh and in Sumatra to capture large earthquakes. To this end, EOS is collaborating with university and government researchers throughout the world.

Although the field of earth science, a new field in Singapore, does not offer much short-term economic benefit, Sieh explains that the investment highlights the government's long-term vision. "What good does it do to spend billions of dollars on better artificial limbs or mobile phones, but then the environment in which you're living falls apart?" asks Sieh. "Our economic value is enormous because we're looking at a 100-year time frame, understanding phenomena that will affect how civilization progresses over the next 100 years."

A boon to NTU's study of the environment came earlier this year, with the launch of Singapore's first locally built microsatellite. Built by NTU with DSO National Laboratories (Singapore's national defense R&D organization), the X-SAT will orbit for three years and take photographs that will help scientists measure erosion and environmental changes while it also captures data for monitoring forest fires and oil pollution at sea.

In this age of international collaborations, NTU has been establishing global networks with other research institutes and industry players. For example, the Energy Research Institute @ NTU (ERI@N), which opened in 2010, is networked with six European universities to collaborate on clean energy research. The institute focuses on improving energy systems and advancing and maximizing alternative energy.

In addition to its academic partnership, ERI@N has also cemented projects with industry leaders, including Vestas, Rolls Royce, Robert Bosch, and the TUM-CREATE Center for Electromobility, set up with Technische Universität München (TUM). TUM-CREATE's first objective is to create an electric car designed for Singapore's tropical megacity, which will carry the potential to expand its system design to other major population centers in Asia.

"NTU has become one of the youngest and fastest-rising universities."

-Bertil Andersson

Taking the lead in the development of new communication technologies, NTU has also partnered with the Swiss Federal Institute of Technology in Zurich and the University of North Carolina at Chapel Hill to set up a S$23 million (18 million US$) research center for telepresence and telecollaboration, called the BeingThere Centre. These new technologies are set to revolutionize the way humans communicate in the 21st century.

The university is also ramping up its engineering and technology strengths in health care, focusing not only on biomedical technology but also on a new medical school it is founding in partnership with Imperial College London, which will open in the fall of 2013. This will help strengthen links between medicine, science, and technology, and will facilitate the development of innovative techniques and products.

In health care, NTU has already produced a series of global breakthroughs. Its deputy president and provost, Freddy Boey, who in 2003 invented the world's smallest piezoelectric heart pump, has gone on to develop several other biomedical inventions, including fully biodegradable stents, a dual drug-eluting stent (that is, a stent placed in the coronary artery to release two drugs simultaneously and slowly), a tissue retractor (to keep wounds open during surgery), and a device to plug holes in the heart, which will enter human trials next year.

NTU scientists have also developed a novel robotic arm that allows scarless surgery to be carried out in the stomach by accessing tumors through the patient's mouth; reengineered a common bacterium to seek out and kill a dangerous superbug resistant to a wide range of antibiotics; and developed a medical tool that calculates an objective measure of a patient's risk from cardiac arrest and stroke.

Viewing the rapid progress already made by NTU, Andersson anticipates its future, expressing his confidence that NTU will attain even greater heights in both research and education.

graphiti

GOVERNMENT CONTENT-REMOVAL REQUESTS AND REASONS

Going Offline

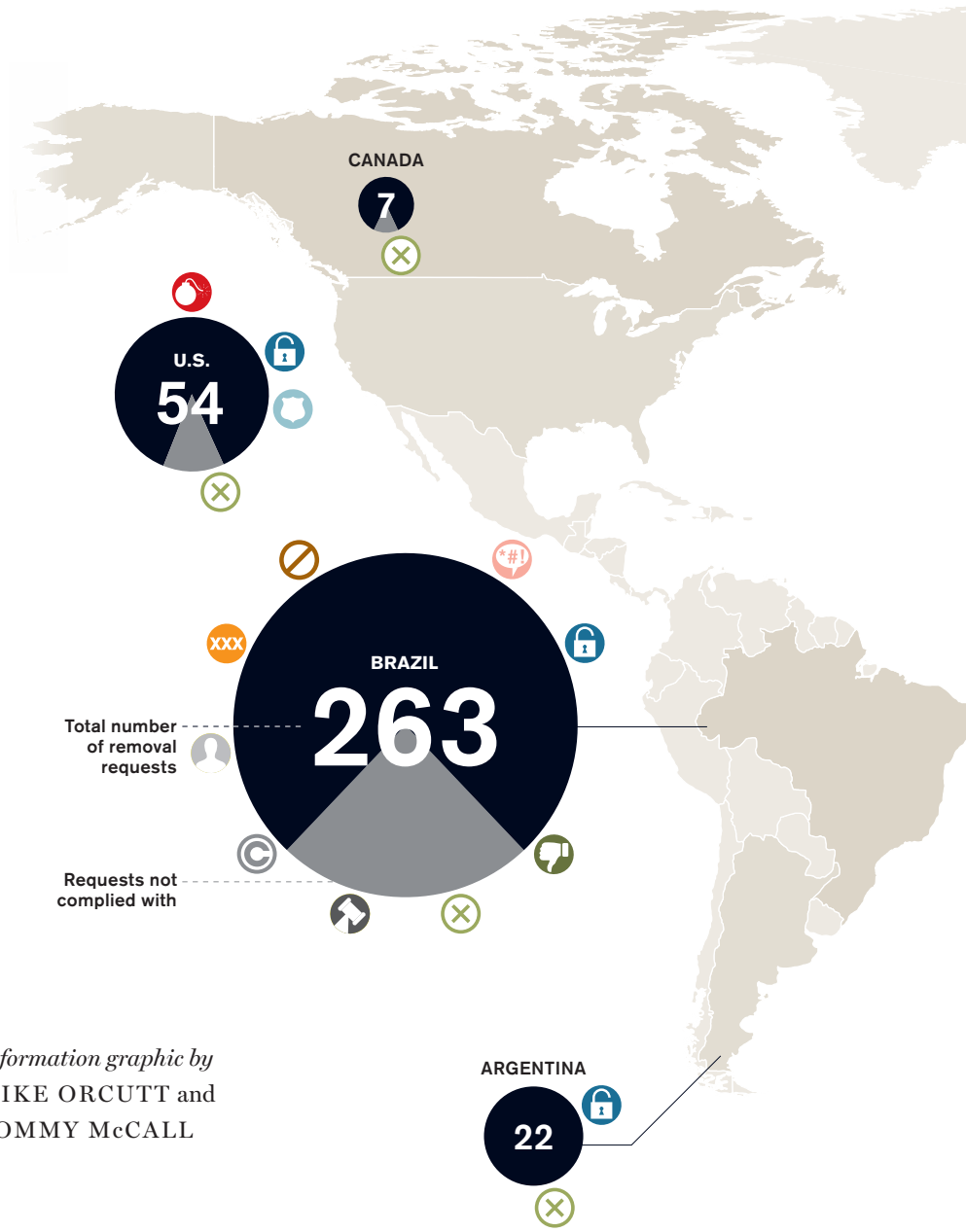
Google reveals how often governments ask it to banish things from its services and how often it complies.

British officials got upset about 93,000 online ads that led unsuspecting people to a Web page for a phony government agency. Thai leaders registered a complaint about 43 YouTube videos that mocked or criticized their king. Argentine courts objected to defamatory material about people that appeared in Web searches.

Such are the insights revealed by Google's Transparency Report. It's a detailed accounting of how many times governments have asked the company to remove content or block it from being seen in their countries. Here we've plotted data from the most recent report, covering the last half of 2010. It breaks out takedown requests by country (in black), the reasons, and the number of requests rejected (in gray). Note that one request can cover multiple items. Google will decline requests for being too broad or vague; it also appears more likely to comply with a court order than a plea from a government agency.

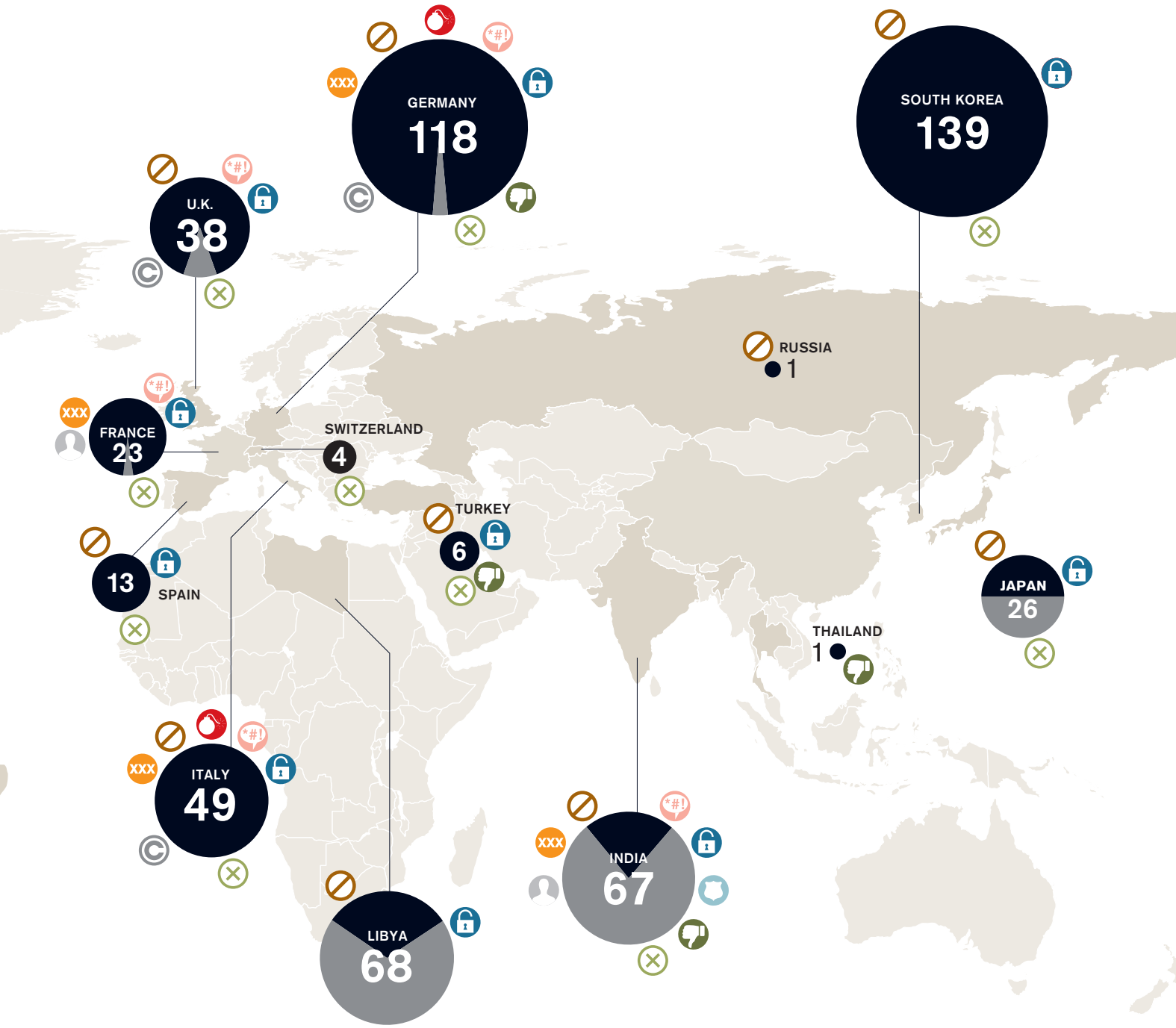
Brazil is the top requester because Google's social network Orkut is so popular there. At the other end of the spectrum, China made no requests. Since Google stopped censoring information for Beijing in the first half of 2010, China has used its "Great Firewall" to block things itself.

—Brian Bergstein



Information graphic by MIKE ORCUTT and TOMMY McCALL

Notes: The governments of Australia, Belgium, Croatia, Denmark, Greece, Hong Kong, Malaysia, Malta, Mexico, Netherlands, New Zealand, Norway, Pakistan, Panama, Singapore, Taiwan, and Vietnam also asked for content to be taken down but are not shown here because they fell below a threshold Google uses when it publishes details—they made fewer than 10 requests and sought the removal of fewer than 10 items. Another section of the Transparency Report, which reveals how many times governments sought data about individuals, is available at google.com/transparencyreport.



COUNTRY REQUESTING MOST ITEMS REMOVED FOR …

Violence	Hate speech	Privacy & security	National security	Gov't criticism	Defamation	Electoral law	Copyright	Imperson-ation	Pornography	Other
ITALY 21 items	**GERMANY** 140	**S. KOREA** 32,086	**INDIA** 16	**THAILAND** 43	**GERMANY** 1,386	**BRAZIL** 35	**BRAZIL** 11,588	**BRAZIL** 68	**INDIA** 21	**U.K.** 93,392

TOMMY McCALL/INFOGRAPHICS.COM

Q&A

Bradley Horowitz

The man building Google's new social network says people deserve better than Facebook and Twitter.

Google mastered Web search and online advertising with math, but to compete with Facebook and Twitter for people's attention it must figure out the trickier domain of human relationships. The task falls mostly to Bradley Horowitz, who helps lead Google's development of social software and recently launched Google+, a network not unlike Facebook.

Horowitz wants it to become a social skeleton that supports every Google product, from search to advertising, with the goal of understanding people, their interests, and their connections. Google failed with earlier social efforts such as Buzz, which aped Twitter. But Horowitz says his team has learned from those mistakes.

He talked to *Technology Review*'s computing editor Tom Simonite about his hopes that Google+ will raise the standard of online social networking.

_TR_: What is wrong with the social networks that people already use?

Horowitz: We heard a lot that people are over-friended. They have an undifferentiated mass of "friends" because there's a social obligation to accept every request, and they end up including everyone from legitimate friends to people they met at a conference to kindergarten classmates.

That inhibits both the quality and quantity of communication. You're stepping up to a podium in front of this diverse group of people where almost nothing can resonate for all of them. That takes conversation down to the least common denominator, so you end up saying things like "stuck in traffic on 101" or "checked in to the Olive Garden." It becomes drivel.

To address that, what assumptions did you make?

Users are faceted. There are many selves that a person has, not just one. We designed our product to recognize that, so that you can have the family self, the pub self, the work self, and special interests like cycling buddies. We're trying to ensure that being social doesn't necessarily mean being trivial or wasting time.

That explains Circles, your core feature, where people organize their contacts into lists. Doesn't that create work for users?

It is a higher cognitive load, because you have to think about who you're going to share something with each time. But we heard again and again that this is a burden that users wanted to bear in return for higher privacy. Privacy should be in your face all the time, not hidden away in a settings menu. We learned from Buzz that people are deeply concerned about privacy, despite this meme about the death of privacy and everything becoming public.

Are you trying to mirror real life more closely than sites like Facebook do?

In some cases we're trying to catch up with the real world online so people's expectations can be met. Our very biology is wired to understand physical constraints and limitations like the fact that sound doesn't travel through walls—not everyone hears every conversation.

Even so, Google+ replicates much of what Facebook and Twitter do. To compete with them you'll have to do entirely new things that neither does, right?

We're only just starting to launch the features that will move the center of gravity of the product and what it's good for. One thing is [Web] search. When you type "kite surfing" into Google+, you will see a live stream of content not only from people you know but also experts in the field, all ranked to be relevant.

How will other Google services change by incorporating personal information?

We recently added "+snippets" to Maps, so you can share exactly what you're looking at on a map with friends, with one click. That's the tip of the iceberg of what you [eventually] could do. When you look up directions, it could tell you of ride-sharing opportunities, or that someone you know is going to be taking the same train. If I'm visiting New York, I could be shown ratings and reviews by people I know that live in or visited the city.

It sounds like you're reshaping the company as well as trying to build a better social network.

I think we are. We have to do this because we've reached a new stage of the Web. The first was the web of links, which Google really transformed with PageRank and Google search. The next phase was the phase of apps, which Google helped drive with things like Gmail and Google Maps. The next will be the web of people—the understanding that it is people who drive the vitality and content online.

The opportunity here is for Google to start recognizing people. When we know who you are, your interests, and who you know—if you let us know that—we can transform all of your activities for the better in search, in Android, in Chrome, in YouTube, in Gmail, and across all we do.

You'll have to move quickly to lure people away from Facebook, which has been adding ideas borrowed from Google+.

We don't need to take users away from Facebook in the early going. [Google as a whole already has] a lot of users and simply needs to introduce them to a new mode of interacting with Google. tr

Photograph by GABRIELA HASBUN

PHOTO ESSAY

A Light in the Desert

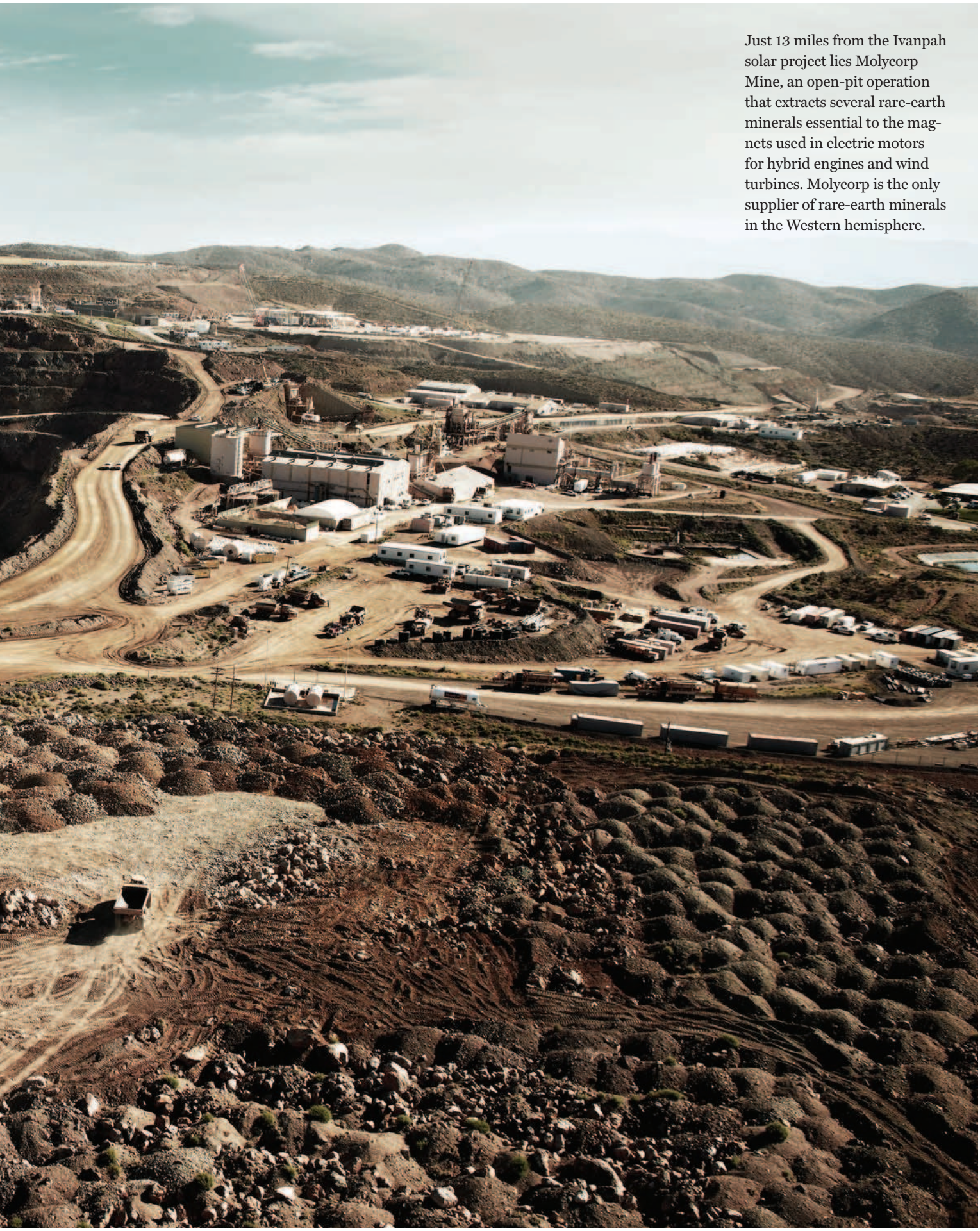
Sweeping across southeastern California and western Nevada, the Mojave Desert includes one of the hottest, sunniest regions in North America, with vast stretches of windy terrain. It is a near-perfect location for solar and wind energy, and it will soon be home to some of the world's largest renewable-energy facilities. Already, these projects are beginning to transform one of the nation's most desolate landscapes.

By KRISTA ZALA *Photographs by* CHAD RESS

In California, near the Nevada border, the first of the new mega-utility-scale solar projects is emerging amid the quartz and cactus. The Ivanpah Solar Electric Generating System, built by BrightSource, will cost an estimated $2.2 billion. It's expected to be bigger than four Central Parks and generate 392 megawatts of power.

The site for the Ivanpah solar project was selected in part for its proximity to existing infrastructure, including gas lines and these high-power transmission lines that ultimately run to Los Angeles.

On the western edge of the Mojave, thousands of windmills dot the Tehachapi range. In spring and summer, the sun bakes the desert air until it rises into the atmosphere and cooler, denser Pacific air rushes in to take its place, most afternoons at about 20 miles per hour. Hundreds more windmills are now under construction. Each can tease three megawatts—enough to power roughly 1,000 homes—from a 45-meter sweep of sky.



Just 13 miles from the Ivanpah solar project lies Molycorp Mine, an open-pit operation that extracts several rare-earth minerals essential to the magnets used in electric motors for hybrid engines and wind turbines. Molycorp is the only supplier of rare-earth minerals in the Western hemisphere.

Crews have just started leveling old farmland for the region's latest solar plant, to be built by Spanish company Abengoa. The land is so alkaline that little but saltbush grows there now. Both the local government and environmental groups endorse the project as a way to make constructive use of the fallow land near existing natural-gas pipelines, transmission lines, and roads.

Even as new projects take shape, the official unemployment rate in high desert towns is often as much as 17 percent; the proportion of people who are out of work or have given up looking may be as high as one in four. In Barstow, about 30 miles from the Abengoa project, close to half the town relies on some form of government assistance, by some estimates. A three-bedroom house sells for as little as $40,000.

A Social-Media Decoder

New technology deciphers—and empowers—the millions who talk back to their televisions through the Web.

By DAVID TALBOT

From his 24th-floor corner office in midtown Manhattan, the veteran CBS research chief David Poltrack can gaze southward down the Avenue of the Americas, its sidewalks teeming. For more than four decades, it has been his job to measure people's television habits, preferences, and reactions. In large part, this has meant following the viewing habits of Nielsen panels of TV viewers and parsing the results of network surveys on their opinions. On a late September afternoon, with fall premieres under way, his desk was strewn with color-coded opinions from 3,000 Americans who had wandered into CBS's Las Vegas research outpost, Television City, at the MGM Grand Hotel and Casino, and agreed to fill out TV surveys for the chance to win a 3-D home entertainment system.

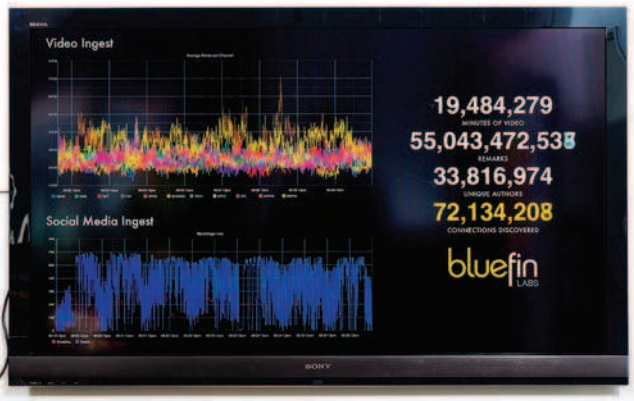
But now he's also dealing with a growing force: the masses talking back through social media. Of the approximately 300 million public comments made online worldwide every day—about two-thirds of them on Twitter—some 10 million, on average, are related to television (though daily numbers vary quite widely). "*¿Que sera two and a half men si[n] Charlie?"* one viewer recently tweeted, alluding to the replacement of Charlie Sheen by Ashton Kutcher on the CBS sitcom. "*The beginning of Person Of Interest is like Jack&Ben all over again,"* remarked another. (A couple of weeks later, another added: *"I assume CBS will keep going with what's been working for them, and replace Andy Rooney with Ashton Kutcher."*) TV executives like Poltrack must now grapple with these spontaneous, messy, irreverent remarks.

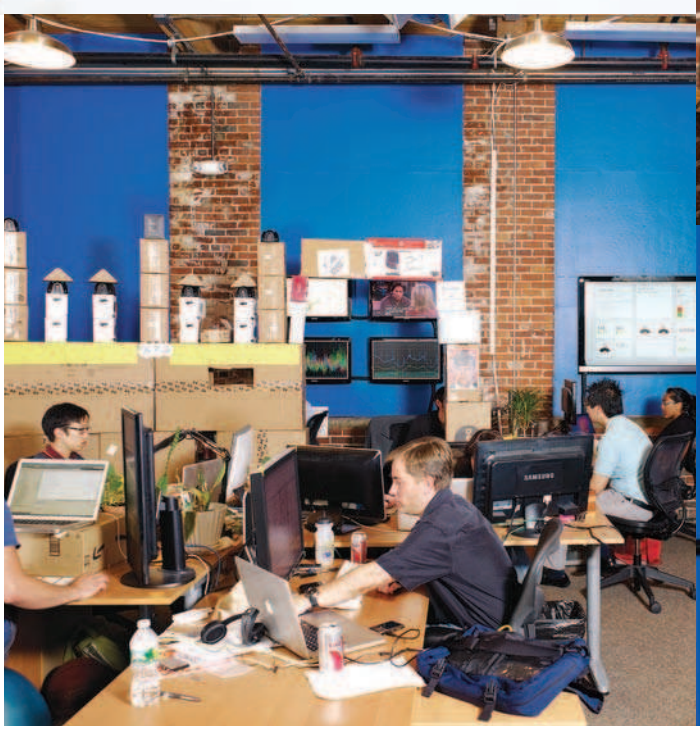
How to make sense of it all? Poltrack walked into the office of a staff member, John Butler, clutching a report from a startup called Bluefin Labs, a social-media analytics firm that attempts to track comments on shows and ads and discern the commenters' interests and demographics. Some of what it had found seemed surprising. For example, the season premiere of *Two and a Half Men* had attracted 78,347 comments compared with 82,980 for *Dancing with the Stars*, on ABC, even though the latter show has lower Nielsen ratings and an older audience that's less likely to participate in social media. (It turns out that reality competition shows, by their nature, attract more active audience response.) Poltrack wondered how a little-watched show called *Bad Girls Club*—on the Oxygen network—had garnered 32,665 comments. "Get *Bad Girls Club* up there," he said to Butler, motioning to Butler's computer screen. "What are they saying?" Butler scrolled through the raw comment string. *"This bitch angie on #Badgirlsclub wear the same damn socks in every episode,"* remarked one viewer; *"BGC, shower & bed,"* announced another. It was hard to know what any of it meant.

Overall, the data was raw and, in many cases, ambiguous. But Poltrack came away with some respect for what he was seeing. "As

Photographs by IAN ALLEN

POWER SHIFT
Deb Roy, CEO of Bluefin Labs, says social media have changed the relationship between media consumers and producers.





a one-time measurement, we have better ones," he said, referring to CBS's precisely constructed surveys. But whereas the surveys are intermittent, social-media analytics can provide "a continuous monitor of conversation about a program, episode by episode," he said. "And that is something we can't replicate." What's more, the quantity of commentary is increasing all the time, making it more important as an object of study and as a force network executives would like to harness. As Poltrack explained, real-world and online chatter—the "exponential movement of a conversation through the population"—drives the success or failure of TV shows and, in turn, the allocation of $72 billion in U.S. television ad spending.

Six hundred miles to the west, a similar assessment was under way at the Cincinnati headquarters of Procter & Gamble, the world's largest advertiser (its brands include Tide, Gillette, Bounty, Pringles, and Duracell). Each year the company spends $5 billion on media ads—the bulk of them on TV—and another $5 billion on in-store advertising worldwide. While Procter & Gamble carefully vets ads with consumers before airing them, it has never known whether the same viewers would respond differently to an ad depending on what show surrounded it.

Craig Wynett, the company's chief learning officer, says Bluefin Labs is teasing out nuances in the way context affects the extent to which an ad generates buzz. One specific product ad (he wouldn't say which) was placed on two shows with similar demographics and ratings. One show produced eight times more social-media response than the other. Nobody knows why, but that's what happened. "Historically, we have held context as a constant. Well, surprise! In the real world, context plays a fundamental role," he says.

PLAYING BALL As a doctoral candidate, Michael Fleischman (above) used televised Red Sox games to teach computers to recognize home runs and other plays. Now the company he cofounded, Bluefin Labs, analyzes social media to decipher mass reactions to TV shows and ads viewed in the United States. In its offices (left), a screen displays the number of comments searched, minutes of TV ingested, and connections found.

Bluefin Labs is one of a growing number of analytics companies parsing the meaning of comments in social media. And its CEO, Deb Roy, believes they are capturing a fundamental change in the relationship between creators and consumers of mass media. "What I have learned by hanging out with TV executives, talent agencies, and creative types is that the assumption is built into their organizations' DNA that this is a one-way dialogue," he says. "Audience members speaking through social media is effectively a shift in power."

In some ways, a two-way conversation has begun. And in future years a TV network could, in theory, continue the conversation by revising its promotions to emphasize characters that have caught on with audiences—or even by revising plot lines midway through a season. Advertisers, meanwhile, could swap out ads—or place them differently—on the basis of the social-media response they get. (Something like this already happens with online ads; increasingly, algorithms use real-time metrics like page views and content changes to guide placement decisions.) In the political realm, campaigns could rapidly determine, among other things, which messages animate people. And early feedback from the first adopters of analytics—network executives and advertisers—could provide clues to wider potential impacts. Wynett says he doesn't know if the people who commented on his advertisement bought the product or "if the message spread until every man, woman, and child heard it." Still, he says, "It's early days, but it shows promise."

MINING SOCIAL SENTIMENT

Analyses of online comments are already influencing corporate, financial, and governmental behavior. Certain companies, Comcast among them, keep an ear open for outbursts of anger to help them detect and respond to service outages and product problems. A London hedge fund, Derwent Capital, makes trades based on the financial calm or anxiety it gleans, in part, from social-media data. And while recent events have suggested that revolutionaries can use social media to help them overthrow some authoritarian regimes *(see "Streetbook," September/October 2011)*, China has learned to manage citizen outrage through measured responses to specific online complaints about matters such as police corruption *(see "China's Internet Paradox," May/June 2010)*.

For marketing purposes, it has become de rigueur for companies to set up Facebook pages and send out tweets, and to keep a watchful eye on the bubbling up of blogged anger. This is true of television networks as well as other companies. For example, Discovery Communications, which runs channels including the Discovery Channel, TLC, and Animal Planet, maintains 75 Facebook pages with 45 million fans, and keeps 23 Twitter accounts crackling with reminders like *"Mythbusters starts in 5 minutes!"* "It's all that beautiful viral effect of social media to get people to watch our shows," says Gayle Weiswasser, Discovery's vice president of social-media communications, "and we aren't the only ones who do it."

To tap the other side of the conversation—the unscripted response of consumers with social-media accounts—companies like Radian6 (now owned by Salesforce), General Sentiment, Sysomos, Converseon, and Trendrr track social-media sentiment and volume on a range of topics. Of course, even the best filtering efforts don't eliminate all spam. And it's not always clear what prompted a post, how a slang-filled tweet should be interpreted, or how to identify the author's demographics. Yet it is "critically important" for businesses to make sense of all this, says Radha Subramanyam, senior vice president of media and advertising insights and analytics at Nielsen: "This is the world's largest focus group, the world's largest town hall. Companies that figure this out will thrive in the next 10 to 15 years. Companies that don't will fail."

It's especially important for TV networks and advertisers. Nielsen says that Americans, on average, spend 20 percent of their day watching TV, and many simultaneously peck away at laptops or mobile devices. Sites like Miso and GetGlue encourage people to discuss favorite shows with friends and other fans. Evidence is emerging that social-media buzz has some relationship to ratings: NM Incite, a Nielsen-McKinsey joint venture, found that among people aged 18 to 34, a 9 percent increase in such chatter in the weeks before a show's premiere correlated to a 1 percent ratings increase.

Recognizing these kinds of connections, sentiment-analysis firms including Trendrr.tv (part of Trendrr) and Socialguide specifically track social response to television content. But Bluefin

is unique in also tracking most of what is on TV—including the ads—to draw specific relationships between televised stimulus and social-media response. "What Bluefin is doing is technically impressive," says Duane Varan, chief research officer at the Disney Media and Advertising Lab in Austin, Texas. Already, it's becoming possible to measure TV viewership directly through cable boxes rather than through samples such as Nielsen panels, he says, and "Bluefin is doing a similar thing with this universe of public social-media discourse."

THE NFL AND SOCIAL TV

Bluefin Labs' headquarters occupy a one-story 19th-century factory that once made hoses, next to a boutique movie theater in the Kendall Square area of Cambridge, Massachusetts. Lego blocks strewn on café tables busy the fingers of visitors or employees at informal meetings. Roy, the cofounder and CEO, sits at one of an open cluster of desks in close quarters with nearly 40 employees, most of them engineers with experience in fields like artificial intelligence, search, and video analysis. A poster showing the "bloodline" of the advertising industry is pinned on a worn wooden post to his right.

Roy, who is 42, is a Winnipeg-born computer and cognitive scientist who until 2008 had spent his entire career in academia, first at the University of Waterloo and then at MIT and its Media Lab, where he became head of a research group called Cognitive Machines. Among other things, his group concerned itself with problems such as how to teach English to robots. In 2005 he launched the ambitiously named "Human Speechome Project" to document how children learn language. Before his son was born, he equipped his home with 11 video cameras and 14 microphones. Then the proud papa recorded (almost) everything that happened in the house to figure out how different adult interactions—as well as activities and objects in different locations of the house—affected the boy's speech development. In 2008, after collecting 300 gigabytes of data every day, Roy stopped. Then he and his graduate students performed feats like charting his son's gradual mastery of the word "water." (A presentation of this process was the hit of the 2011 TED conference and has spread virally throughout the Internet.)

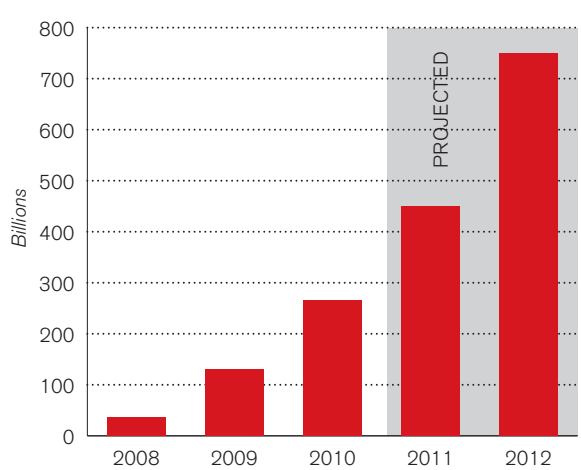
The project married linguistic analysis with video analysis, but it was Roy's PhD student Michael Fleischman, now 34, who made the conceptual leap to TV. For his dissertation, Fleischman initially planned to use lessons from the speechome project to teach computers language. But there was a problem: "It became clear to me that I'd have to wait until Deb's son grew up," Fleischman says. "I needed to find a new data set." The answer came, appropriately, in front of the television. One night, while watching a Red Sox game with his girlfriend (now his wife), Fleischman realized that televised sports had what he needed: visual action, play-by-play dialogue, and sufficient repetition and structure. So he started creating software that would turn baseball games into a language-teaching tool. The spoken words "home run," for example—when accompanied by a camera angle arcing across a stadium—might lead the computer to learn how to distinguish an actual home run. After *Technology Review* wrote about the baseball-interpreting technology, he and Roy were invited to apply for a $100,000 National Science Foundation Small Business Innovation Research grant.

In 2008, Fleischman and Roy got the grant and named the company after a sushi restaurant where they'd discussed their plans. The initial focus on sports led to angel investments from sports magnates including Jonathan Kraft, president of the New England Patriots; Jim Pallotta, an owner of the Boston Celtics; and Dan Gilbert, majority owner of the Cleveland Cavaliers. (As of October 2011, the company had received $8.5 million in funding, mostly from Redpoint Ventures but also from angel investors.) Bluefin's first customer was the National Football League, which already had a new online feature called "Game Rewind" that let fans review already-played games. Fleischman and Roy expanded the concept by tying the video stream to social-media comments. They tuned search algorithms to look for football-related keywords; the result was an on-screen interface that let fans read, play by play, what others had written. (This turned out to be an early instance of the now-popular trend in social TV applications.)

During this process, Roy and Fleischman had another "Aha!" moment. The comment stream that turned up for televised games had blank patches at regular intervals. "We looked and said, 'What's

CONVERSATION STARTER

The total number of social-media comments is rising sharply, providing more fodder for analysis. Most of these are public.



Source: Gnip. Figures reflect both public and private instances of active participation in online conversations: tweets, comments, and other posts.

NETWORK EFFECT David Poltrack, chief research officer for CBS, has long recognized the value of viewer conversations about shows. Now he's evaluating tools that scrutinize millions of comments made about TV online.

that?'" says Roy. "Well, those were the ads." It hadn't occurred to them that people would talk about ads. But they do. They write—as one recently did, in a tweet picked up by Bluefin—things like *"The dude rappin in the mcdonalds commercial about the smoothies will forever be clowned where ever he goes."*

Roy and Fleischman realized that the advertising industry might be interested in understanding more about such comments, and advertisers had large research budgets. "We took the principles of big data, data mining, and visualization," Roy says, "and turned that microscope [in my house] into a telescope to look at the world of social media as it relates to television." They called their work the "TV genome." Today Bluefin has 15 clients, including Pepsi, Mars, and Comcast; the TV networks CBS, Fox Sports, A+E Networks, AMC Networks, and Turner Broadcasting; and the ad agencies McGarryBowen and Hill Holliday. The company business is selling subscriptions to its interface and custom analytics. While making these conquests, Roy encountered a language learning issue of his own. "When I started talking to people in TV, I'd hear the word 'programming.' Turns out they weren't talking about programming software," he recalls. "It took me a while to figure this out."

INSIDE THE TELESCOPE

In order to capture almost everything happening on television, Bluefin uses a data center studded with satellite dishes in Medford, Massachusetts *(see "Heeding the Tweets," next page)*. Through the first week of October, they'd pulled in every minute of more than 210,000 episodes of 7,100 television shows, plus advertisements. The company now monitors 200 networks.

After uploading the raw feed to Amazon's cloud computing service, Bluefin gathers programming-guide information—the names of the shows, their broadcast channels and times, and also the names of characters and actors—along with closed-captioning text extracted from the video signal itself. This provides a list of keywords that can help identify relevant social-media comments. Since advertising schedules are not published ahead of time, Bluefin creates one. The algorithm detects when a "pod" of ads has started. Then a system of digital fingerprinting identifies repeat airings; human staffers are notified of first-time airings to make the initial identification.

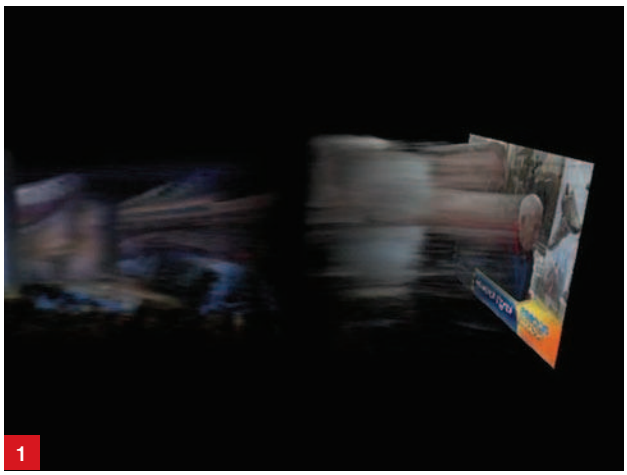
Among the more than 10 million comments made daily about TV content, Bluefin's algorithms identify about 1.4 million that are made in the three hours before or after a show or advertisement aired on one of the networks it tracks. (About 90 percent of these comments are tweets; the bulk of the remainder are public Facebook posts.) Although on-demand services, recording technologies, and new Internet models of TV delivery are changing viewing habits *(see "Searching for the Future of Television," January/February 2011)*, most people still watch television the old-fashioned way, and Roy says they seem more likely to make real-time comments when they know they are watching the first airing. Bluefin also keeps close tabs on the 9.8 million people who have commented about television at least once in the past 90 days, to build up knowledge about their demographics and interests.

Text analysis underpins all these efforts: whereas "delicious" or "tasty" might indicate a positive response to a restaurant, terms like "can't wait" or "fascinating" or "drivel" might show up in comments related to TV shows. Bluefin is working on identifying not only positive or negative reactions but ones that are vulgar or polite, serious or amused, calm or excited. "At the highest level, what we are trying to do is language understanding," Fleischman says. It also tries to glean demographic information about who is commenting. Women, for example, are more likely to refer to family members, while men are more likely to mention friends or electronic devices. Emoticons hint at age: someone who uses :-) is probably 10 years older than someone who uses :). People using 8-) are even older.

Bluefin ultimately turns all this data into two main measurements. "Response level" reports the number of people commenting on any given ad or episode of a show, measured on a logarithmic 10-point scale. "Response share" measures what percentage of all social-media response to television programming at a given airtime focused on a particular show or ad. The company's first interface—Bluefin Signals, which provides analytics on comments about TV shows—went live in June. A second, which is due for release in December, will track response to individual ad campaigns. Next year Bluefin plans to include Spanish-language comments in its analysis.

HEEDING THE TWEETS

How Bluefin analyzes what you say about TV



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1. Video intake
Every day, Bluefin ingests video from 200 television networks, representing about 90 percent of the programming viewed by U.S. audiences. It also captures the name and time of the show, the names of characters and actors, and closed-captioning text of the show's dialogue. It tracks advertisements as well. Machines detect ads; humans electronically tag new ads, and video fingerprinting technology detects and tracks repeat airings.

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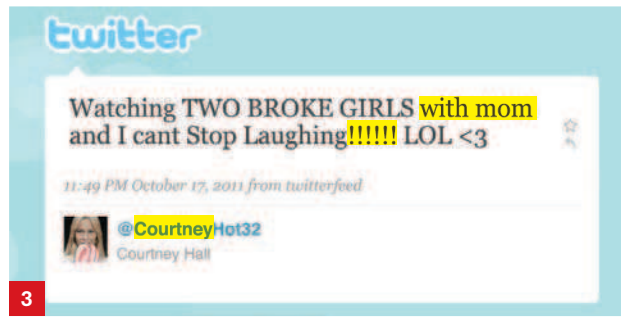
2. Social-media intake
At the same time, Bluefin scans 300 million public social-media comments daily for keywords associated with the video signals it has processed. The system seeks relevant comments that appear in the three hours before or after a show is broadcast, suggesting that the words are not being used in some other context. Each day, about 1.4 million comments fit these criteria.

3. Text analysis
For comments about TV, Bluefin seeks clues about the author's gender and age. In this example (based on a real tweet but edited and anonymized), a female screen name, use of multiple exclamation points, and references to family members are hints of female authorship. The system keeps track, in anonymized fashion, of posters' commenting habits—especially what TV shows and ads they comment on over time.

4. Patterns and associations
Bluefin makes many kinds of associations that could be valuable for programmers, marketers, and, someday, politicians. For example, women who talk about Diet Coke in social media also discuss reality shows more than other kinds of programming, with *Russian Dolls* topping the list. But men who mention Diet Coke in social media tend to discuss talk, news, or comedy shows the most, especially Mike Huckabee's program on Fox News. Such information can, in theory, do things like help ad buyers determine which slots best provoke audience "conversation," but proof of its value is still under study.



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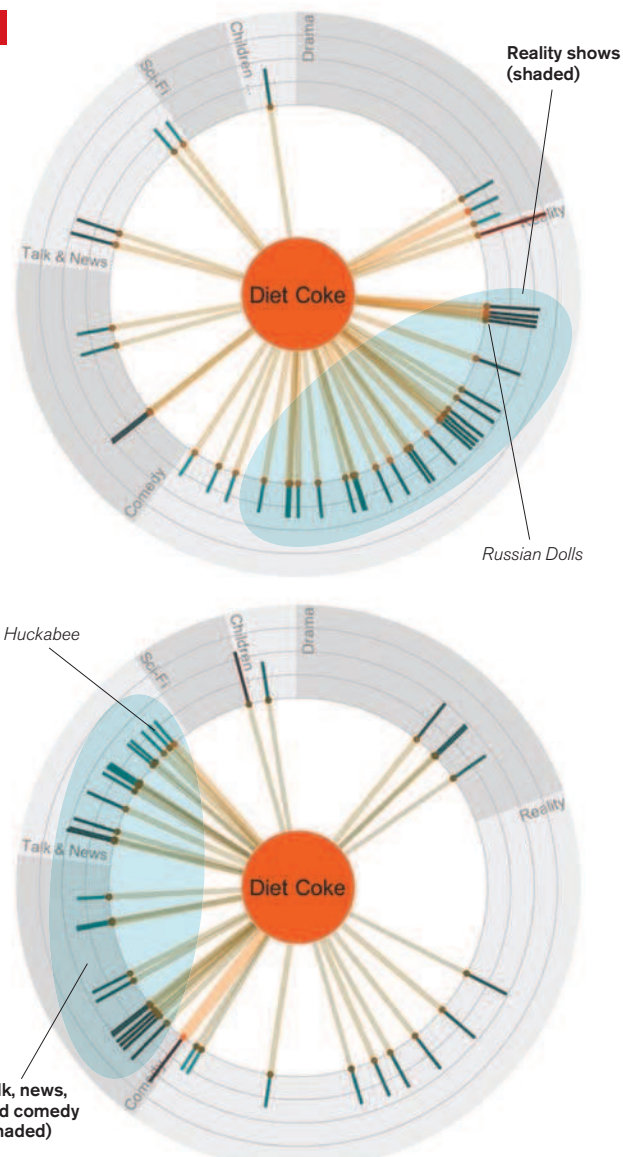


BLUEFIN LABS

Roy says there is no reason why the company couldn't track television signals and analyze the sentiments expressed through social media in other countries, too. So far, though, there are no immediate plans to expand beyond the United States.

HOW PEPSI RESONATES

Bluefin can tell you certain things very clearly, and one of them is the degree to which audiences are moved to talk about Diet Pepsi when a swimsuit-clad Sofia Vergara is involved. Vergara, who plays the Colombian trophy wife on the comedy *Modern Family*, appeared this past summer in a widely aired commercial in which she met soccer heartthrob David Beckham on a beach. Traditional social-media analysis showed a 7 percent increase in chatter about the drink during the time the campaign aired. But Bluefin knew the ad had run exactly 746 times, on 260 different shows, and it knew who had commented on those 260 shows during the commercial's run. Among those 1.8 million people, mentions of Diet Pepsi were up by 19 percent. Bluefin was also able to determine that in June, a spike in negative sentiment about the Hyundai brand throughout social media coincided with the premiere of a TNT science fiction drama, *Falling Skies*, during which commenters complained that a promise of "limited commercials" had been broken.

Such insights could be a boon to television advertisers wondering what ads to place and where to place them. "If I'm moved by comedy, drama, or sheer creativity in an ad, then I have a propensity to talk about it," says Mike Proulx, senior vice president for social media at the ad agency Hill Holliday. "There is a theory—and it's unproven—that the greater the social-media mentions, the higher the content's resonance."

The new tools could also complement analytics like those provided by Simulmedia, a New York City company that licenses anonymized viewing data from 18 million set-top boxes. "Bluefin is able to associate specific delivery of an ad to positive sentiment in some target audience," says Dave Morgan, Simulmedia's CEO. "That alone is becoming a key marketing objective. It's no longer just 'Spend a certain amount of money on sex, age, income'; it's 'Spend money that causes positive sentiment from a target audience.'"

Of course, the applicability of Bluefin's data goes only so far. For one thing, most conversations still happen in the real world, not online; according to one market research firm, KelleyFey, 90 percent of the conversations people have about brands in the United States happen offline. Further confusing matters, "people who use social media are not representative of the general population, it's very difficult to understand the differences, and it's a dynamic, variable thing," says Varan, the Disney research executive. "There is so much we don't know about how the social-media universe differs from the real universe. So the danger is looking at the kinds of results that Bluefin would produce and drawing conclusions that it's a reflection of what the overall population is doing."

MAKING OF THE PRESIDENT, 2012

Fleischman and Roy predict, however, that applications will ultimately go well beyond TV, helping to reveal the events and media sources that inspire people in radio, newspapers, and magazines, as well as online. "You can look at the affinity from any one thing to any set of things," Fleischman says. "Pop culture expands fairly widely—politics, media, actors, books, plays, religion. The tail gets longer and longer, to anything you can imagine people talking about. If you are looking for a set of people with a particular interest, we can tell you how this relates to another set of interests."

The next obvious area for Bluefin is politics. Early next year, in time for the presidential primary season, the company expects to analyze social-media reaction to speeches, televised debates, and political advertisements. "What's potentially more interesting is understanding who, positively and negatively, is making connections between audience members," Roy says. Already, social media have become a key political organizing tool *(see "How Obama Really Did It," September/October 2008)*. But political operatives are tough customers: they care mainly about two things. First, in presidential races, they care what undecided voters in swing states think. And second, they want to know who, among their reliable base of supporters, is willing to take some action, such as donating or spreading a message. Comments in social media are of limited value.

Still, political operatives might be just as interested as Procter & Gamble in learning which messages are resonating. Andrew Heyward, former president of CBS News and a Bluefin advisor, thinks such analyses could be vital for political commentators and anchors, too. "Getting almost real-time feedback on scale and sentiment is very valuable for a political organization or a candidate—or a news organization trying to cover the race," he says.

The value of social-media analytics will only rise. The number of comments is growing every month, and Roy predicts that analytical technology will improve as algorithms are refined and as more participants crunch the data and pursue yet-unimagined applications. Today, conversations in social media are still hard to overhear and decipher. But what might someday emerge from Bluefin, or one of its competitors, are technologies that make those conversations easy to capture and understand—and produce a metric akin to a Nielsen rating. (The Nielsen and McKinsey findings about the correlation between buzz and ratings are a step in that direction.)

In the future, then, marketing officers and network executives such as David Poltrack may be able to leave the survey takers back at the Vegas slot machines and tune in to a continuous social-media conversation that is now either inaudible or incomprehensible. They may see ways to create television programming, advertising, political communications, and ultimately other media that are smarter—or at least more responsive to what audiences find appealing. tr

DAVID TALBOT IS *TECHNOLOGY REVIEW*'S CHIEF CORRESPONDENT.

Alberta's Oil Sands Heat Up

Thanks to its deposits of buried bitumen, Canada is one of the world's fastest-growing oil producers. New extraction technologies are opening up even more of the vast resource—prompting fresh environmental concerns.

By PETER FAIRLEY

For many, images of Canada's boreal forest torn apart by sprawling operations that clear the land and strip off the top layer of earth have come to symbolize the environmental evils of petroleum in the 21st century. The so-called surface mines, which uncover rock-hard deposits of sand and clay rich in the heavy, sticky mixture of hydrocarbons called bitumen, now account for a substantial portion of Canada's oil exports, including much of the petroleum going to the United States. But the face of the industry exploiting northern Canada's oil sands is changing—and possibly becoming even more troubling.

Head south or west from Fort McMurray, the Alberta boomtown hosting many of the strip mines and tailings ponds that have made the province's oil industry infamous, and the mines give way to tidier industrial sites amid boggy greenish-brown muskeg and stands of white spruce, jack pine, and aspen. These forest-ringed facilities have traded shovels and enormous trucks for an extraction process that drills down hundreds of meters into solid ribbons of bitumen and, using vast quantities of steam, melts the tarry petroleum in place. Liquefied bitumen then oozes out through a system of parallel pipes. Such "in situ" extraction operations now account for nearly half the current output of northern Alberta's oil business, and that figure will only increase. Alberta's 1.8 trillion barrels of bitumen may be the world's largest single accumulation of hydrocarbons, but four-fifths of this resource lies deeper than strip-mining can reach.

In situ extraction is expensive—on average, it's not profitable if world oil prices are below $60 per barrel. But with today's prices consistently well above that, the practice is booming. The oil sands will generate over 1.5 million barrels of oil per day this year, according to the Canadian Association of Petroleum Producers, a Calgary-based group. That accounts

Photographs by KRISTOPHER GRUNERT

STEAM SOLUTION
Pipes connect the wells at Christina Lake. One pipe delivers steam to the wells; the others return the bitumen-water mix and natural gas from the wells.

for more than half the oil that Canada pipes to the United States (Canada is its neighbor's single biggest source of imported oil). By 2025, oil-sands production is projected to more than double, to 3.7 million barrels per day, and in situ operations will deliver nearly two-thirds of that boost.

The catch is that while the drilling might seem on the surface to be less destructive to the environment than strip-mining, in many ways the newer technology is far more damaging. Even though the drilling sites don't ravage the landscape the way the mines do, they use vast amounts of energy and consequently produce lots of carbon dioxide. Using steam to flush out bitumen accounts for 2.7 percent of Canada's total greenhouse-gas emissions, or an estimated 19 megatons of carbon dioxide last year—equal to the annual tailpipe emissions of 3.7 million cars. It creates more than twice the production emissions of conventional oil-sands mining. Independent experts say that by the time the bitumen is refined and delivered to gas stations across the United States, it has already accounted for two or three times as much greenhouse gas per gallon of fuel as gasoline refined from conventional crude.

Most worrisome, the drilling operations in the oil sands are just one example of the increased production of "unconventional" oil, formerly hard-to-exploit sources that recent technological advances have made economically viable. Such resources in the Americas alone include huge amounts of bitumen-like oil in Ven-

VAST RESOURCES An aerial view shows the surface mining near Fort McMurray in the foreground, while refining and tailings ponds abutting the Athabasca River are visible in the background.

ezuela, deep undersea oil reserves off the coast of Brazil, and "tight oil" held in shale deposits throughout the United States and Canada. The geological resources and technologies used to produce unconventional oil vary greatly, but they all require extraction processes that are energy intensive and environmentally destructive. Oil sands are the principal reason why Canada's annual greenhouse-gas emissions, which the government promised to cut to 558 megatons by next year, now exceed 710 megatons and are projected to reach 785 megatons by 2020.

The reality is, however, that the world has quickly become reliant on unconventional oil, including the oil sands, as global energy demand has continued to grow faster than supply. And the Canadian economy, particularly in Alberta, has become heavily dependent on the growth of the oil-sands industry. Investments from Canadian firms and global oil giants totaled $13 billion in 2010 and grew to $16 billion this year. The oil sands have made Alberta the hottest place in Canada for jobs, investment, and growth, helping the country avoid many of the economic woes afflicting the United States and much of Europe.

The oil sands mean hundreds of millions of dollars in taxes and royalties, and job creation from Newfoundland to Vancouver. So many Newfoundlanders have come to Alberta to work in Fort McMurray that it amounts to "Newfoundland's third-largest city," says Murray Smith, a former Alberta energy minister. Such economic heft makes it a given that Canada is going to keep exploiting this resource, he says: "We're next door to a customer that has 250 million vehicles driving three trillion miles a year. You can be sure that as long as that demand is there, there will be product to sell. We'll produce the oil sands."

AGE OF STEAM

Christina Lake, a rapidly expanding in situ extraction operation 120 kilometers south of Fort McMurray, is truly remote. Though clear-cutting, natural-gas production, and gravel mines have etched the forests, mule deer and moose still outnumber humans. Christina Lake's closest neighbor is the hamlet of Conklin, population 300, and to the south is the Cold Lake Military Air Range, a vast no-man's-land reserved for aerial combat exercises and tactical-weapons tests. The sense of isolation is evaporating, however, as thousands of workers install and run billions of dollars' worth of equipment at Christina Lake and more than a dozen other sites in Alberta.

Much of the world's oil, including the vast reserves of "conventional" oil in places such as Saudi Arabia and the Gulf of Mexico, is a mixture of hydrocarbons that gushes up from the ground and flows easily at room temperature. The Canadian oil sands, on the other hand, are tarry deposits in which the hydrocarbons coat the sand and clay. Once removed from the ground, the oil has the viscosity of cold molasses. Extracting it must, in essence, reverse natural forces that created the bitumen beginning millions of years ago, when the rise of the Rocky Mountains pushed fast-flowing light petroleum into adjoining layers of buried sand.

For nearly a century, entrepreneurs have struggled to separate the solidified deposits from the sand and make them into liquid hydrocarbons again. Fort McMurray's mines opened in the 1960s and early 1970s and limped along with government support until oil prices began rising in the late 1990s, encouraging investors.

GAS GUZZLERS Massive steam generators at Christina Lake burn natural gas to produce vast amounts of steam, which is injected into 375-meter-deep wells to heat the tarry oil and allow it to be sucked up to the surface. An experimental version of the technology adds a solvent to the steam to make the bitumen extraction faster and more efficient (opposite page).

Alberta's in situ sites are the product of a government-financed research project initiated in 1974 to lift the oil-sands industry beyond strip-mining. By the late 1990s, the provincial project had settled on a technology: steam-assisted gravity drainage, or SAGD. Cenovus, the Calgary-based company that operates Christina Lake, created the first commercial SAGD site in 1999 and began pilot tests at Christina Lake three years later.

While more sophisticated than strip-mining, in which bitumen less than 75 meters below ground is simply dug up after the top layer of earth is removed, SAGD is still largely a brute-force method of sucking up deeply buried bitumen. At Christina Lake, pairs of perforated wells sink 375 meters deep, reaching a layer of bitumen 25 to 30 meters thick. There, the wells flatten out to run 800 meters horizontally through the lower third of the deposit, one well five meters above the other. Steam is forced through the top wells at 250 °C to heat and eventually melt the bitumen, which drains away from the sand, clay, and other minerals. The bottom "production" wells then suck a mix of water and melted bitumen to the surface, where the water is separated from the bitumen and recycled. Finally, the bitumen is blended with a hydrocarbon diluent to make it thin enough for pipelines before being handed off to an adjacent oil terminal and beginning its journey to refineries in the United States.

Above ground, Christina Lake is a buzz of activity. The site ships more than 16,000 barrels of bitumen per day. In August, Cenovus completed an expansion that cost approximately $900 million in Canadian dollars and increased capacity to 58,000 barrels per day. Now the site is in the throes of two equivalent expansions that have swelled its staff to nearly 2,000 people who work, eat, and sleep on site for seven to 10 days at a stretch. There is plenty more growth to come, says Drew Zieglgansberger, the senior vice president responsible for Christina Lake. Zieglgansberger expects that by 2019 the site will be generating over 250,000 barrels of bitumen per day—enough, he says, to gas up all the cars in Illinois. He says it should sustain that pace for 30 years.

The site itself is more like a medium-sized chemical plant than a mining facility. Towering over it are five 32-meter-tall steam generators; four more are under construction. These mammoth furnaces burn natural gas and blast out 250 million BTUs of steam per hour. In all, says Zieglgansberger, they put out the heat equivalent of 50,000 backyard grills. (With every hour of combustion and heat from Christina Lake's steam generators comes 75 metric tons of carbon dioxide emissions—roughly 45 kilograms of carbon dioxide for every barrel of bitumen.)

The bad news for Alberta's oil-sands industry is that Christina Lake is a best-case scenario for SAGD today. Zieglgansberger needs to steam just two barrels of water to produce a barrel of bitumen, making it Alberta's most efficient in situ operation. His competitors (and most future SAGD operations) must target thinner bitumen deposits, some streaked with rock and water that divert injected heat. As a result, the average barrel of bitumen produced via SAGD last year required just under three barrels of steam, according to

Alberta's Energy Resource Conservation Board. That's why, once shipping and refining are taken into account, Alberta's in situ production process creates far more greenhouse-gas emissions than making fuel from conventional crude.

Those figures are nothing but scandalous to John Nenniger, the founder and CEO of N-Solv, a Calgary-based startup exploring technologies for exploiting oil sands. Nenniger says that the industry has improved little since the first SAGD field pilot in the late 1980s: "That very first test had a steam-to-oil ratio of 2.38. Since then the steam-oil ratios have actually deteriorated. There's been no progress at all."

PAYBACK?

It's not as if no one is trying. Large oil companies, including Shell, Suncor Energy, and Exxon subsidiary Imperial Oil, as well as entrepreneurial startups such as N-Solv and Laricina, are field-testing a growing number of in situ techniques. Some are pumping air deep underground and igniting some bitumen in hopes of melting the rest more efficiently. Others see potential in using electricity to heat deeply buried bitumen.

Cenovus is testing a method that uses a combination of steam and a solvent, butane, to help loosen up the bitumen. Pad A02 looks like any other at Christina Lake, except that it has just one pair of wells supported by some extra hardware: three 50-foot-long storage tanks for the butane and equipment to blend it with the 250 °C steam that roars in by pipe from the steam generators. Adding that equipment boosts the cost of building a new site by almost a third, but it's worth it, says Harbir Chhina, Cenovus's executive vice president for oil sands. Chhina says adding butane delivers 10 to 15 percent more bitumen from the same resource and does so roughly 30 percent faster.

The effects of that improvement on energy use, profits, and greenhouse-gas pollution are to get a first commercial-scale test at Narrows Lake, an in situ project immediately northwest of Christina Lake where Cenovus hopes to be producing 130,000 barrels of bitumen per day by 2016. (Approval for Narrows Lake is expected by next summer; Alberta has never rejected an oil-sands application.) Chhina's prediction: Narrows Lake's steam-to-oil ratio will be around 1.7, 15 percent lower than it would be without the solvent. He says the technology could decrease greenhouse-gas emissions by as much as 30 percent at most SAGD sites.

Meanwhile, Nenniger is gearing up for tests of a solvent-only process that was invented in the 1970s by his father, who was vice president for process engineering at Hatch, Canada's second-largest engineering firm and N-Solv's majority shareholder. From a makeshift work space in Hatch's Calgary offices, Nenniger plots the technology's comeback: a $60 million pilot test is under way at Suncor Energy's Dover site northwest of Fort McMurray, the same place where the SAGD process was originally tested.

Nenniger estimates that eliminating the use of steam and lowering temperatures will save $9 on each barrel of bitumen. What's more, the solvent process can extract the best-quality bitumen, leaving more of the heaviest asphalt-like materials in the ground. That should make N-Solv's bitumen easier to refine, fetching producers an extra $15 for every barrel they ship. Nenniger also projects that the process will use 80 to 90 percent less energy per barrel of bitumen than SAGD, reducing carbon emissions accordingly.

N-Solv plans to drill observational wells at its pilot facility this winter, and injection and production wells should follow in the summer. Warm solvent could begin flowing as early as the fall of 2012, delivering production results by the following summer. Nenniger projects commercial-scale application in as little as five years. "Proving we're better than SAGD on a head-to-head basis will open up the entire oil-sands market," he says.

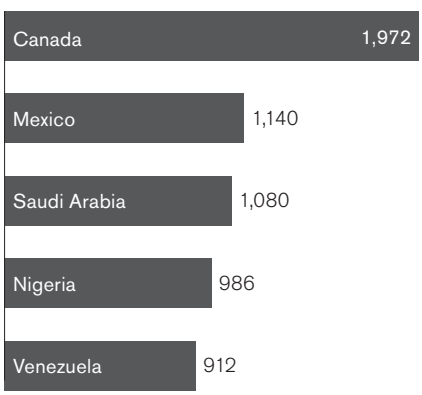
The question for oil-sands innovators is whether the financial risk of developing new types of in situ technologies will pay off.

WHAT PEAK OIL?

Alberta's vast reserves of bitumen are among the world's largest sources of crude oil.

The United States has already become reliant on Canada's oil ...

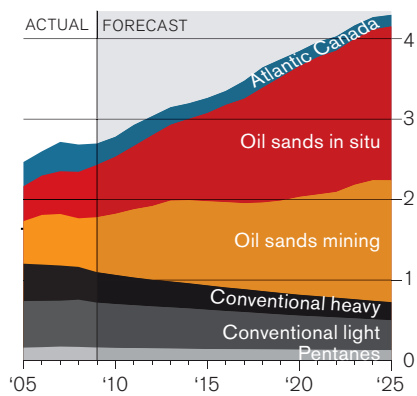
Top sources of U.S. crude oil imports
(thousands of barrels per day in 2010)



Source: U.S. Energy Information Administration (EIA)

... much of which comes from Alberta's rapidly growing oil-sands production.

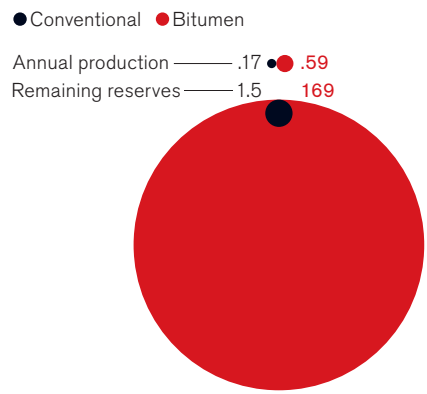
Canadian oil sands & conventional production (million barrels per day)



Source: Canadian Association of Petroleum Producers (CAPP)

Indeed, Canada's oil reserves are almost entirely in the bitumen deposits.

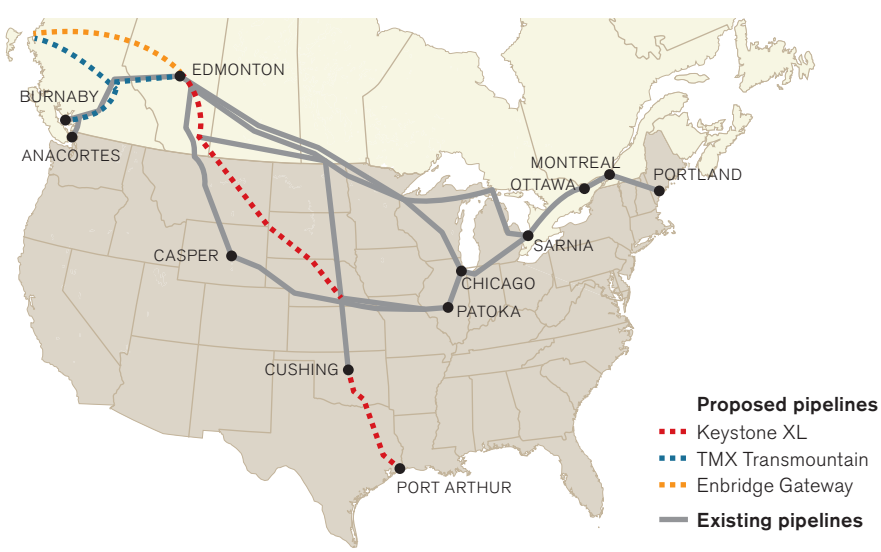
Alberta oil reserves and production, 2010
(billion barrels)



Source: Energy Resources Conservation Board (ERCB)

The proposed Keystone XL pipeline would deliver oil from Alberta to refineries in Port Arthur, Texas, adding to an existing network of pipelines to the United States.

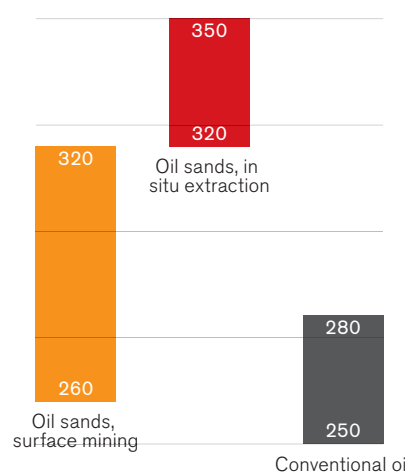
Selected Canadian & U.S. crude oil pipelines



Source: CAPP

Energy used to process oil sands results in large releases of carbon dioxide.

Greenhouse-gas emissions during the production and consumption of gasoline from oil sands and from conventional oil
(grams of CO_2 equivalent per kilometer)



Sources: Joule A. Bergerson, Alex D. Charpentier, and Heather L. MacLean; Environmental Research Letters

TOMMY McCALL/INFOGRAPHICS.COM

Cenovus needs a global oil price of just $45 to $50 per barrel to turn a profit on its Christina Lake investments; with prices now above $75 per barrel, it is making good money. In an era of cheap natural gas and pricey oil, Canada's bitumen producers will need an extra push before they commit billions of dollars to alternatives to mining and SAGD. Nenniger believes that corporate decision makers have little incentive to change under current economic conditions, where energy costs are low and tax-deductible, and carbon emissions are free. "You have a system that doesn't create market pull," he says.

Says Heather MacLean, a professor of engineering and public policy at the University of Toronto, "There has to be some type of a policy push … to really motivate the most efficient production and reduction of greenhouse gases and other environmental impacts." What is needed, she says, is a price on carbon. Two years ago, Alberta introduced a carbon tax of $15 per ton, but that covers only a portion of industrial emissions, and even oil executives dismiss its impact on investments. "It's in the tens of cents per barrel," says Zieglgansberger.

A BIGGER PROBLEM

This summer, leading climate-change activists made the Alberta oil sands a household name with two weeks of protests in front of the White House. The action targeted the proposed Keystone XL pipeline, which would deliver half a million barrels of petroleum per day to refiners on the U.S. Gulf Coast through a 36-inch pipeline running 2,673 kilometers from Alberta to Port Arthur, Texas. More than 1,000 protesters, including NASA climate scientist James Hansen, were arrested. President Obama is scheduled to make a final decision on the pipeline this winter.

Ken Caldeira, one of 20 leading climate scientists who issued an open letter to the president opposing Keystone XL, argues that stopping it would increase the cost of marketing Alberta's bitumen and thus provide a de facto carbon pricing signal to producers. "We collectively are offering a free subsidy to the fossil-fuel industry by allowing them to dump their waste in the atmosphere," says Caldeira, who is an atmospheric scientist at the Carnegie Institution of Washington in Stanford, California. "We should remove that subsidy."

Caldeira says the ultimate problem he sees with oil-sands investments is that they threaten to reinforce dependence on petroleum, and petroleum combustion in vehicles generates over a fifth of global carbon dioxide emissions. Improving the extraction process for oil sands will only make that dependence deeper. With current methods, the Alberta government estimates, 169 billion barrels of bitumen in the oil sands can be produced economically—less than a tenth of the buried resource. More efficient technologies will yield that much more oil to be burned in the world's cars and trucks. "If we want to evolve to a low-carbon energy system, we shouldn't be building additional fossil-fuel infrastructure," Caldeira says.

Stopping the Keystone XL pipeline could have unintended consequences, however. If President Obama blocks the project, producers will still sell their bitumen, sending it in rail tankers or through proposed pipelines to Canada's Pacific ports. Meanwhile, slowed bitumen production in Canada would probably prompt producers elsewhere to meet the enduring demand for fuel by exploiting resources such as oil shale, hard-to-control deep-sea wells, or even coal. Discouraging oil-sands production is not likely to stanch the global flow of petroleum, says Adam Brandt, a professor in Stanford University's Department of Energy Resources Engineering: "The market forces are just overwhelming." MacLean agrees. "Countries importing large volumes of oil today are not going to stop doing that tomorrow," she says. "They're not all moving to electric vehicles in the next decade. So having a policy of no further fossil-fuel infrastructure doesn't really seem realistic to me."

A number of experts say that reducing overall oil demand is ultimately the only way to lessen the environmental impact of Alberta's oil-sands industry, and a widely respected 2009 meta-analysis of life-cycle studies by MacLean and fellow life-cycle analysts Alex Charpentier and Joule Bergerson at the University of Calgary would seem to back them up. According to the analysis, driving a car for one kilometer produces 320 to 350 grams of carbon dioxide pollution if the gasoline is derived from in situ plants. If the gasoline is refined from conventional crude, the same ride produces less pollution—250 to 280 grams of carbon dioxide. But the combustion of the petroleum itself, regardless of how the fuel was produced, accounts for 212 of those grams either way.

With current methods, the Alberta government estimates, 169 billion barrels of bitumen in the oil sands can be produced economically—less than a tenth of the buried resource. More efficient technologies will yield more oil to be burned in the world's cars and trucks.

The bottom line, says Brandt: "If we're really upset about the oil sands, we need to get serious about our oil habit." tr

PETER FAIRLEY IS A FREELANCE WRITER BASED IN VICTORIA, BRITISH COLUMBIA. HIS FEATURE "WILL ELECTRIC VEHICLES FINALLY SUCCEED?" APPEARED IN THE JANUARY/FEBRUARY ISSUE OF *TECHNOLOGY REVIEW*.

Can This Man Work Magic?

Nokia helped invent the cell-phone business, but those days of technology glory are long gone. Its new CTO has the job of creating the technologies and designs that will help the Finnish company regain its status as an innovation leader.

By WILLIAM M. BULKELEY

In a conference room on the sixth floor of the vast glass-and-steel building housing Nokia's research labs in Helsinki, Igor Curcio, an Italian-born computer scientist who specializes in signal processing, demonstrates a prototype of one of his favorite projects. Called Director's Cut, it is an automated, crowd-sourced video production service. A small group of people who go to an event—a concert, a wedding, a soccer game—can capture video on their cell phones and then upload it to the service. Its computers synchronize the videos with the help of their time stamps, analyze sharpness and exposure to get the best pictures and sound quality, and decide what to include in a final composite video by figuring out how many of the cell-phone users got pictures of the same thing.

In a demonstration video made from a live concert in Finland, quick cuts from one camera angle to another give a professional look to the three-minute show. Multiple audio tracks create stereo sound. The clip looks ready for broadcast on low-definition television.

What's not clear is who would want such crowdsourced video, or whether Nokia could make a business out of it. Curcio, who has worked as a radio-station disc jockey, suspects that people would enjoy the opportunity to create more professional-looking videos of weddings, family reunions, concerts, high-school sports events, and other shared experiences. He also says a service that encourages people to use bandwidth uploading pictures and video is likely to be attractive to Nokia's crucial partners: the wireless carriers that sell its phones. But it may not be possible to provide this service to the public. Nokia's lawyers are concerned about the digital rights to audio and video from concerts, sporting events, and even weddings where music is played.

You might say that projects like Director's Cut are all too common at the company's labs. Nokia spent 2.9 billion euros on handset R&D last year—far more than any competitor, and twice as much as Apple spent on R&D of all kinds. But in recent years, such lavishly funded efforts have failed to produce any technology that would allow Nokia's products to compete with the iPhone and other new smart phones. "Nokia was the king of the mountain, with the largest budget," says Howard Anderson, a venture capitalist and a senior lecturer at MIT's Sloan School. He says the company was "blindsided" by Apple's iPhone, which was designed primarily as an Internet device while Nokia and others were designing phones with add-ons. Jason Armitage, a London-based mobile-media analyst at the Yankee Group, says that Nokia adopted a classic strategy for dominant players: it segmented the market and provided different

Photographs by AKI-PEKKA SINIKOSKI

WHITE KNIGHT?
Nokia's new CTO, Henry Tirri, needs to match its large R&D effort with the company's urgent business needs.

R&D HOT SEAT Hannu Kauppinen (above) oversees such Nokia research projects as innovative ways to produce video (center) and a flexible, stretchable phone prototype that uses nanotech materials.

products for every customer class. "It missed seeing the opportunity to invent a whole category with a single killer design," he says.

As a result, Nokia is rapidly losing its leadership position in one of the world's fastest-growing markets, wireless communications—a market that it helped invent. Its sales of low-end phones fell 16 percent in the second quarter of this year compared with the second quarter of 2010, and its sales of more expensive smart phones fell 34 percent for the same period. Nokia dominated the early days of the worldwide smart-phone market with phones based on the Symbian operating system, but Apple products and now Google's Android phones have leapt ahead. "Symbian is now regarded as a dumb smart phone," says Anderson. With its revenue dropping, Nokia's market value has been cut in half over the past two years, wiping out more than $30 billion in shareholder wealth. That has put the future of this 150-year-old company in question.

Henry Tirri, Nokia's new chief technology officer, may play a bigger role than anyone else in determining that future. Tirri, who previously led some 500 researchers as head of the Nokia Research Center, stepped into the job earlier this year after the company brought in a new chief executive, Stephen Elop, in hopes of figuring out a better strategy. Elop, the former head of Microsoft's business division and the first non-Finn to head the company, outsourced all software development and support for Symbian to Accenture—transferring about 2,300 people to the consulting firm—and announced that Nokia would rely on Microsoft's Windows Phone developers for its future smart-phone software. The company will lay off another 4,000 people next year, and in September it closed a Romanian factory and announced plans for 3,500 more layoffs.

Now Tirri is expected to "set the course for Nokia and our role in the mobile industry," Elop said. And he doesn't have a lot of time. As the CEO said in an interview that was webcast by Nokia, "We have to go faster and harder and more aggressively now than we've ever gone before."

It is a daunting challenge for the 54-year-old Tirri, a Finnish machine-intelligence researcher who now lives in Silicon Valley. Tirri, who is also a professor at the University of Helsinki and the Helsinki University of Technology, says that as head of the research labs he "looked at future disruptions." Now he also has to "nurture the Nokia technical community," negotiate joint work with Microsoft, oversee the company's intellectual-property strategy, and develop innovations for both the high-end smart-phone market and the business of making low-priced phones for Africa and Asia, the last places where the company still dominates.

SNIFFING OUT OPPORTUNITIES

At Nokia headquarters in the Helsinki suburb of Espoo, Tirri, who jets frequently between Finland and California, has an office with a view of firs, birch trees, and an arm of the Baltic Sea. His soft-spoken demeanor is more that of an academic than a corporate executive. And Nokia remains committed to basic research, he says: "At times like this, clever companies maintain research. Research

opens options." Despite the layoffs in other parts of the company, he says, Nokia hasn't made significant cuts in investments for its labs.

As head of research, Tirri says he views himself as a kind of venture capitalist who gets proposals from lab directors based on projects started by researchers. The lab directors are like angel investors who authorize preliminary work and then select the few ideas worthy of being assigned to research groups. Projects that will require teams of 30 or more have to hold the promise of creating businesses worth $1 billion or more for Nokia, which had $56 billion in revenue last year. Tirri says that even though business conditions have worsened for Nokia, and development—especially for software—has been cut, its research labs around the world are pushing ahead with work that may be just a few years away from yielding products.

Tirri once described his main research interest as "reasoning under uncertainty"—teaching machines to make decisions on the basis of probabilities. And he will surely need to reason under uncertainty as he negotiates the tumultuous cell-phone industry, which in a single 10-day period this past summer was upended by Google's purchase of Motorola, Apple CEO Steve Jobs's resignation, and Hewlett-Packard's decision to abandon tablets and its WebOS. Tirri says that the Motorola and HP announcements made Nokia look smart for deciding to rely on Microsoft for operating-system development, because it is becoming clear that Windows will be one of only three or four main smart-phone operating systems for consumers and software developers to focus on.

Even with Microsoft producing the operating system for advanced phones, Tirri says, Nokia has plenty of opportunity to "innovate on top of the platform." One main area of innovation is cognitive radio technology, which he believes could lead to phones with nearly unlimited bandwidth and lightning-fast response time. The idea is that even as more and more mobile devices compete for bandwidth, much of the radio spectrum remains underutilized. In many places, for example, analog television bandwidth is barely used because stations broadcast digital signals instead. In some countries, police and fire departments, and even taxi companies, have bandwidth reserved for their transmissions. Cognitive radio would make use of otherwise idle bandwidth by analyzing the environment, "dynamically asking whether space is available" on each slice of the spectrum, and deferring to a preferred user only if that user needed it at the moment, says Hannu Kauppinen, who took over from Tirri as research director. As part of a consortium of companies, Nokia has received permission from the U.K. government to use the "white space" in existing television frequencies for a trial in Cambridge, England, and Kauppinen is hopeful that broader use will be approved "if we can prove we don't cause interference."

Pushing the boundaries of radio research will be the only way to prevent future cellular traffic jams, Nokia believes. Kauppinen says the technologies the company's researchers are investigating could "improve the speed of wireless communications up to 10 times." Nokia researchers have already designed and produced an integrated circuit that can "sniff" channels to find unused spectrum.

> "At times like this, clever companies maintain research. Research opens options," Tirri says. Despite layoffs elsewhere in the company, he says, Nokia hasn't significantly cut investment in its labs.

Regulatory issues block the way to putting this technology in action, however. "We still have to live in the regulatory era of 100 years ago, when one channel was allocated to one use," he says.

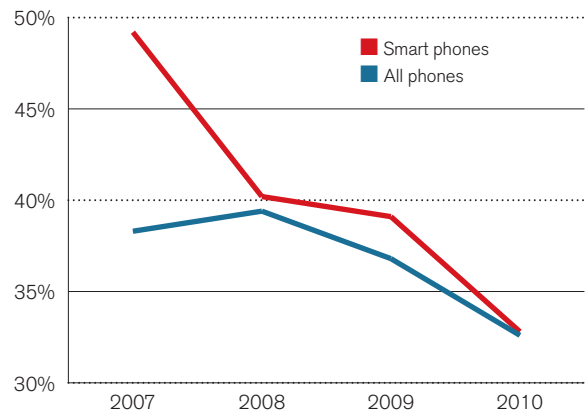
RUBBERY PHONES

Another major research area involves nanomaterials such as graphene, which Nokia researchers believe could enable the company to redesign and reshape handsets. Graphene is a super-strong, atom-thick form of carbon that is flexible, transparent, and highly conductive. Tapani Jokinen, Nokia's head of design technology, is intrigued by its potential. He has been working on prototypes of flexible phones, using graphene for the circuitry, that could be bent, stretched, or wrapped around a forearm like a wristwatch. "It's like a stretchable electronic skin," he says.

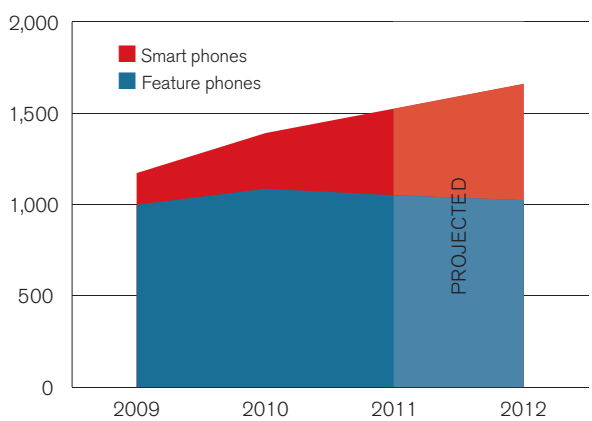
Nokia has also developed technology that would use graphene in flexible haptic displays, which could deliver information through the sense of touch. One possibility is "haptic navigation": a flexible

CALL 911!
Nokia's position is plunging

The company's share of phone sales is dropping ...



.... while the overall smart-phone market soars
(in millions)



Source: IDC

phone handset would signal the person holding it to turn left or right by pressing against the hand in one direction or the other. Other potential uses of nanomaterials include an "electronic nose" in which silicon nanowires on a chip could identify particular molecules in the air. Incorporated into a handset, it might warn a user of allergens in restaurant food.

Tirri, meanwhile, sees potential for Nokia to create a major new business in location-based technology. The company owns the widely used Navteq mapping service, the principal alternative to Google Maps. Researchers believe that combining this with tagging technology could have a variety of useful applications.

Using low-power antennas placed on the ceiling, Nokia researchers can determine the location of an object equipped with a Bluetooth-enabled tag to an accuracy of 30 centimeters. The tags communicate with a cell phone via Bluetooth, and then the phone orients the user by means of a preloaded map. One way to use such a system would be in stores: a user would enter a shopping list into a cell phone equipped with near-field communication, which is already used for payment and other functions in some devices, and the screen would display a map showing where to find the desired products. The phone could also display special offers on products the shopper passed while navigating the store. In a home with a few locators installed, tags could be attached to keys, television remotes, eyeglasses, and other frequently misplaced objects.

EVERYWHERE

Despite its struggles to compete with Apple and Google in the smartphone market, Nokia still sells more phones than any other vendor. About 1.3 billion people around the planet own Nokia phones. Its ring tone may be the most-played musical theme ever. With its $56 billion in sales last year, it is one of the biggest technology companies in Europe, and its success is a source of national pride for many of Finland's 5.4 million people. Indeed, Nokia, which started 150 years ago as a paper mill, helped invent the cell-phone business in 1991 by leading the development of GSM, the first mobile digital network technology. A year later, in 1992, it pioneered SMS text messaging. It built the first phone without an exterior antenna in 1998. In 2005, it sold its billionth phone, a Nokia 1100 in Nigeria. That model, introduced in 2003, may have been the best-selling consumer-electronics product ever, with about 250 million handsets sold.

Whether Nokia survives is arguably quite important, particularly in emerging markets, where it remains dominant. It is best placed to provide smart phones to many poor people who want to upgrade from less capable handsets. Its handsets support 80 languages, and it has been spectacularly successful in selling low-priced devices in emerging economies—markets that Apple isn't close to cracking. Researchers in its Beijing labs developed a way for users to continuously write Chinese characters using a stylus, one character on top of the last, on small smart-phone touch screens; they found that the handheld devices could use various clues to more accurately recognize what the user was trying to write. "Two billion people don't have data connections—only SMS," Tirri says. That means touch-entry technologies for texting are crucial.

Nokia won't challenge the iPhone with a jellyfish phone that can be wrapped around the wrist. But the company's strong presence in many parts of the world gives it a unique opportunity to once again redefine how more than a billion people communicate. tr

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ESSAY

World Without Walls

When everything that can be recorded is recorded, our means of protecting privacy must fundamentally change.

By AARON BADY

People have long worried that technology is destroying privacy. Today, the lament focuses on Facebook; but as far back as 1890 William Brandeis, a future Supreme Court justice, and his associate Samuel Warren were decrying the unprecedented assault against privacy by the new media of their day: tabloid newspapers and cheap photography. The two Boston lawyers were defending what they called a "principle as old as the common law"; their article, "The Right to Privacy," was probably the most influential law-review article ever written.

But Brandeis and Warren had it backward. When they laid the foundations of modern privacy law, they were inventing something strikingly new: a generalized right "to be let alone" that was unmentioned in the Constitution or the Bill of Rights. In the 18th century, publicity was such an exception to the norm that privacy didn't need to be named, much less legally protected. Along with the miles of fields and forest that kept neighbors out of one another's business, a very simple artifact—walls—effectively frustrated snooping eyes. Keeping secrets was sufficiently easy that Americans felt they controlled the extent to which their activities were private. With the establishment of a national postal service in the late 18th century, that began to change. As an increasing amount of private information began to circulate routinely through a public infrastructure rather than being transmitted by private couriers, traditional privacy technologies began to fail. It was no longer enough to seal letters closed with wax and an individualized seal, for example; once a letter or package was in the mail, a person could do almost nothing to ensure that no one but its intended recipient would open it. So in 1878 the Supreme Court ruled, for the first time, that the Fourth Amendment (which guards against unreasonable search and seizure) protects the contents of a letter as if it were still in the sender's home, establishing a legal right to privacy in correspondence. When Brandeis and Warren proposed a new tort—the invasion of privacy—they were seeking to further extend legal rights to protect a person's sense of uniqueness, independence, integrity, and dignity from the depredations of emerging technologies.

We see this pattern repeating itself again and again, with technologies ranging from the postal service to e-mail. As old techniques for protecting proprietary information lag behind new technologies of information circulation, the law seeks to restore the *status quo ante*, making difficult and expensive what has become easy and cheap—in effect, seeking to do the work that was once done, silently, by walls, closed doors, or sealing wax.

This legal model is inadequate for an age of networked information. Brandeis and Warren were concerned with the kind of privacy that could be afforded by walls: even where no actual walls protected activities from being seen or heard, the idea of walls informed the legal concept of a reasonable expectation of privacy. It still does. Today police cannot use thermal imaging to penetrate the sanctity of the bedroom without a warrant, because the law protects the thing that's notionally closed away, making opaque the barriers through which modern technology can see. But this is a deficiency of contemporary privacy law: only information that is walled off is protected. Opening a closed or locked door, listening through a wall, breaking the seal of a letter, and tapping a private phone all require a warrant, for example. But contemporary threats to privacy increasingly come from a kind of information flow for which the paradigm of walls is not merely insufficient but beside the point.

Illustration by JAMES DAWE


CAMERA AXIS

In the last 50 years, the sheer density of the information environment has reached and surpassed the point at which privacy might be maintained by walls. And a legal system built on a presumption of information scarcity has no chance at protecting privacy when personal information is ubiquitous. We shouldn't worry about particular technologies of broadcast or snooping—for instance, the way Facebook trumpets our personal information or deep packet inspection allows governments to trawl through oceans of Internet data. The most important change is not the particular technologies but, rather, the increase in the number of pathways through which information flows.

In the 1980s, Roger Clarke coined the term "dataveillance" to describe the kind of surveillance that becomes possible as we move from a world in which personal information is rare and expensive to one overflowing with data. The idea of data mining, for example, makes no sense in an information-scarce environment: the proverbial tree that falls when no one is watching does not get recorded, and it never becomes data. Today, more and more personal information is recorded, and collecting, standardizing, processing, and monetizing vast pools of it has become big business. The private data broker Acxiom, for example, has an average of 1,500 items of data on the 96 percent of Americans currently in its databases. Along with networked computing, a decline in data-storage costs means it is easier to record everything that can be recorded—and indefinitely store and circulate everything—than to sort through it to determine what is and what isn't worth keeping. The baseline of our information environment has become a tendency toward total availability and total recall.

When we talk about privacy and surveillance, it is impossible to avoid mentioning *1984*, George Orwell's dystopian account of a world without walls, where television watches you and microphones record every sound above a low whisper. But Orwell said nothing about dataveillance. And while the Fourth Amendment guarantees protection from the kinds of governmental invasions that tend to concern Americans the most (reading our mail, searching our homes), when we think about the problem this way we tend to overlook the kinds of knowledge discovery that don't require anyone to break into anything.

Data mining as criminal investigation is a good example. Investigating a suspect's known associates is an ancient tactic in policing, but it costs money, time, and effort, and it's legally complicated; investigations tend to be constrained by a high threshold of initial suspicion. But as the amount of widely available data rises, another kind of search becomes possible. Instead of starting from a subject of suspicion and placing that person within a map tracing patterns of behavior and networks of associates, it becomes feasible to begin with the whole map and derive the subjects of suspicion from the patterns one finds. Pattern-based data mining, in other words, works in reverse from a subject-based search: instead of starting from known or strongly suspected criminal associations, the data miner attempts to divine individuals who match a data profile, drawing them out of a sea of dots like the pattern in a color-blindness test. Dataveillance draws powerful inferences about people and their associates from deep and rich—and often publicly available—records of otherwise routine behavior. Automated systems monitor the environment to match the profiles of particular users to pattern signatures associated with criminal behavior, using algorithms to track and analyze anomalies or deviations from what someone, somewhere, has deemed normal.

Existing privacy protections are largely irrelevant to this kind of surveillance. The Fourth Amendment protects only what is said in a conversation. But much the way pen registers and tap-and-trace devices (which record which numbers you dial, who calls you, and how long you talk) do not trigger the same Fourth Amendment privacy protections that a wiretap would, telecommunications companies are not banned from amassing and selling vast databases of call data. The Supreme Court has ruled that once information about call "attributes" passes into the possession of a third-party carrier like a telecommunications company, it effectively becomes the property of that third party, which may collect, store, and circulate it as it pleases.

Before it was easy to store, index, and access such information, the privacy implications were minimal. But as the government's network analysts turn their attention to the databases of telecommunications information collected by companies like Acxiom, or simply provided by telecommunications companies themselves, the basic process of criminal investigation is being turned on its head. It becomes more practical—and legally less complicated—to fish in an ocean of easily available information about everybody than to target specific suspicious individuals.

Law enforcement has long been interested in "intelligence-led policing," but pattern-based data mining and predictive network analysis gained considerable momentum after the 9/11 Commission blamed intelligence-sharing breakdowns and a failure to "connect the dots" for the attacks of September 11, 2001. Intelligence agencies had been keeping secrets from each other. The more that was known about Osama bin Laden and the threat posed by al Qaeda, for instance, the higher the level of secrecy classification rose on that information, and this had the effect, ironically, of preventing it from being shared within the intelligence services. As the United States has reorganized, expanded, and integrated its intelligence, law-enforcement, counterterrorism, and homeland-security agencies in the last 10 years, these agencies have been tasked with predicting and preventing terrorism. And so, as federal and state agencies have begun to develop the tools and processes that would make predictive policing possible, they have sought not only to take advantage of ongo-

ing trends in the broader information environment but also to shape and expand that environment.

The United States has not built a centralized spying agency. In 2002, Congress ordered the creation of an "effective all-source terrorism information fusion center" that would "implement and fully utilize data mining and other advanced analytical tools." The same year, the Department of Defense's Advanced Research Projects Agency (DARPA) announced a "Total Information Awareness" research program that would develop new technologies for data collection, data mining, and privacy protection. The TIA program was to have been managed by a centralized agency called the Information Awareness Office, but a bipartisan backlash led to the IAO's termination in 2003. Along with the scope of its ambition, its logo was a public-relations disaster: the all-seeing eye and pyramid from the dollar bill, along with the Latin phrase *Scientia Est Potentia* ("Information Is Power").

Yet the goals of TIA, and even some of its research projects, were not abandoned when the Information Awareness Office was shuttered. As Siobhan Gorman reported in the *Wall Street Journal*, many of TIA's component parts were quietly reconstituted elsewhere in DARPA or in the secretive National Security Agency. Steve Aftergood of the Federation of American Scientists called the defunding and reassembly of some of TIA's projects a "shell game," while the American Civil Liberties Union has questioned whether the government was attempting to replace "an unpopular Big Brother initiative with a lot of Little Brothers."

At the same time, an initiative called the Information Sharing Environment (ISE) was undertaken to create a decentralized network for information aggregation and distribution. In contrast to the Information Awareness Office, the Information Sharing Environment is less an organization than an interagency "approach." As the ISE's most recent report to Congress put it, it is "analogous to the interstate highway system": "The ISE represents the structure and 'rules of the road'—including commonly understood road signs, traffic lights, and speed limits—that allow information traffic to move securely, smoothly, and predictably ... If built properly, everyone can use the roads."

The office of the program manager of the Information Sharing Environment is small and unimposing, with only about a dozen full-time employees; most of the work is done by private contractors, whose number is much larger. But as Kshemendra Paul, the current program manager, emphasized last year, the ISE mandate is not to "pour the concrete" itself, but to coördinate the "data-centric" infrastructure through which information is shared among mission partners, a category that includes federal, state, and local agencies, the private sector, and international allies.

Most of what the Information Sharing Environment does is in the realm of standardization: it works to develop, coördinate, and expand across all levels of government the indexes and mechanisms of interoperability that allow agencies to share with one another. For example, the Nationwide Suspicious Activity Reporting Initiative expanded and standardized a project, originally developed by the Los Angeles Police Department, to report, tag, and circulate "observed behavior that may be indicative of intelligence gathering, or preoperational planning related to terrorism, criminal, or other illicit intention." As a result, a Suspicious Activity Report filed by one agency can now be shared (and be mutually comprehensible and indexable) across all levels of government. This is an example of the "data-centric" approach, in which a variety of "Rosetta Stones," as Kshemendra Paul calls interoperability standards, allow data to move as freely as possible among authorized agencies. At the same time, to ensure that information is shared only with those tasked to use it, a working group within the Information Sharing Environment has been developing a program called "Simplified Sign-On," which would allow users of one sensitive law-enforcement database to access all others within a single government-wide system.

The Fourth Amendment guarantees protection from the kinds of governmental invasions that tend to concern Americans the most (reading our mail, searching our homes), but when we think about the problem this way we tend to overlook the kinds of knowledge discovery that don't require anyone to break into anything.

Within the Information Sharing Environment, a new kind of information-sharing site has evolved since 2006: the "fusion center." A fusion center is a node of intelligence dissemination, where representatives of federal, state, and local government gather to share and "fuse" intelligence both with one another and with representatives of private companies and foreign governments. Each fusion center is different in structure and in scope. So far, there are 72 of them, the majority under the authority of state governments. The underlying concept is both expansive and simple: to facilitate information sharing both by "co-locating" representatives of partnering agencies under one roof and by using those partnerships to connect and circulate information of potential interest, such as Suspicious Activity Reports.

To accomplish their goals, fusion centers take what is called an "all crimes, all hazards" approach, which not only is "flexible enough for use in all emergencies" but is by design as open-ended as possible. As John Pistole, a former deputy director of the Federal Bureau of Investigation, put it, "We never know when something that seems typical may be connected to something treacherous." So fusion centers put a premium on total data sharing, a mind-set in which more is always better. Rather than sorting, processing, and classifying information, they connect existing repositories of information almost indiscriminately and with a single-minded institutional logic. Meanwhile, terms like "threat" and "information" come to be defined more and more loosely. As a 2007 Manhattan Institute white paper noted, "Consistent with the all-hazards approach of many fusion centers, the term 'threat' indicates any natural or man-made occurrence that has the possibility of negatively affecting the citizenry, property, or government functions of a given jurisdiction."

The 2010 Fusion Center Privacy Policy Template explicitly states that information is to be kept only for appropriate uses, but the systemic logic of fusion points in the opposite direction. Fusion centers are specifically designed, after all, to circumvent restrictions on information sharing—to replace a system of "need to know" with a system of "need to share," as the 9/11 Commission put it. Moreover, since pattern-based network analysis starts from the big picture, it makes no sense to limit the available data to what is already deemed suspicious. Instead, fusion centers work to give all partnering agencies and entities something as close as possible to universal access to all information in the system. Anything that might prove relevant is to be made available to any who might use it. This means, in practice, that lines drawn to separate different areas of concern (and define areas of specific regulatory oversight) become blurred as a matter of institutional necessity.

In a 2006 essay, Danielle Citron and Frank Pasquale argued that fusion centers pose a legal and privacy conundrum because they operate "at the seams of state and federal laws" for the sake of circumventing traditional accountability measures. An oversight apparatus that assumes there are solid walls between discrete agencies cannot regulate them. The Privacy Act of 1974, for example, specifically regulates what kinds of information federal agencies are allowed to keep. But state agencies like fusion centers—though they are staffed, funded, and directed by the federal government and fully integrated into it—operate outside that jurisdiction and circulate information that the FBI can therefore access without officially possessing.

This loophole is built into the network's structural logic at every level. While law enforcement and intelligence agencies are required to keep personally identifiable data only in the demonstrated interest of criminal investigation, the Information Sharing Environment is designed to let agencies and agents access otherwise inaccessible information in databases held by third parties. Moreover, the list of information that can legitimately be accessed, and therefore circulated, is almost endless. As Robert O'Harrow Jr. has reported in the *Washington Post*, fusion centers collect traffic tickets, property records, identity-theft reports, driver's license listings, immigration records, tax information, public-health data, criminal-justice sources, car-rental records, credit reports, postal and shipping records, utility bills, gaming data, insurance claims, data-broker dossiers, and more. The information age makes the amount of broadly accessible information incomprehensibly massive, and the Information Sharing Environment aims to circulate it within the government with as little friction as possible.

In addition, partnering with private industry has long been a priority. Information Sharing Environment guidelines specify that "critical infrastructure" is a prime terrorist target and mandate that because "the private sector owns and operates an estimated 85 percent of infrastructure and resources that are critical," agencies should "develop effective and efficient information sharing partnerships with private sector entities." In practice, this has meant incorporating representatives of the private sector into fusion-center operations at the highest level. In a case seen to be exemplary for other fusion centers, a Boeing analyst is employed full time at the Washington Joint Analytical Center, where Boeing trades its "mature intelligence capabilities" for "real-time access to information from the fusion center." Another Information Sharing Environment partnership, an FBI initiative called InfraGard, is intended to facilitate the sharing of information and intelligence between private business and the intelligence community. According to its website, it now has more than 45,000 members, including representatives of 350 of the Fortune 500 companies. But there is almost no oversight. The Critical Infrastructure Protection Act of 2002 specifically exempted information provided by the private sector from the Freedom of Information Act disclosure requirements, and InfraGard's website notes that all its communications with the FBI and Homeland Security fall under "trade secrets" exemptions.

Jay Stanley of the ACLU has argued that there should be no "'business class' in law enforcement" and that "handing out 'goodies' to corporations in return for folding them into its domestic surveillance machinery" carries risks. But can this kind of *quid pro quo* be avoided when the point of the network is to facilitate information flow? According to a Congressional Research Service report, fusion-center leaders often feel that expanding the mission beyond counterterrorism is the best way to get the private sector and local law enforcement to buy in. To acquire data that might prove useful in counterterrorism investigations, in other words, the mission of the Information Sharing Envi-

ronment had to creep. But while it's not difficult to speculate about what sorts of bargains must be struck between government agencies hungry for information and third parties who hold that information, the broad rubric of counterterrorism cloaks the details of fusion-center activities in secrecy even as the structural logic of the centers places them outside traditional modes of government oversight.

It is difficult to know what kinds of information circulate through the Information Sharing Environment, since most fusion centers do not own or store records but simply provide access that allows information to be disseminated among partners. When the New Mexico ACLU filed an open-records request on New Mexico's All Source Intelligence Center, for example, the lack of a "material product" meant there were no records to open. But as Citron and Pasquale have pointed out, "a critical mass of abuses and failures at fusion centers over the past few years makes it impossible to accept [privacy] assurances at face value."

More disturbing, Bruce Fein, a former associate attorney general in the Reagan administration, has gone so far as to argue that fusion centers conceive the business of gathering and sharing intelligence as "synonymous with monitoring and disparaging political dissent and association protected by the First Amendment." Several examples have been well publicized—for instance, a Virginia fusion center named historically black colleges as potential terrorist hubs—and at least one fusion-center official has confirmed that the boundaries between what's considered dissent and what's considered terrorism are blurring. After police officers in Oakland, California, used wooden bullets, concussion grenades, and tear gas to break up an otherwise peaceful antiwar protest at the Port of Oakland in 2003, it was revealed that a California fusion center, the California Anti-Terrorism Information Center, had led the police to expect Black Bloc anarchists to make a violent effort to shut down the port. The spokesman for the center argued, "If you have a group protesting a war where the cause that's being fought against is international terrorism, you have terrorism at the protest. You can almost argue that protest is a terrorist act."

Kim Taipale, a specialist in security technology, has argued that the defunding of the Information Awareness Office may prove in retrospect to have been a pyrrhic victory for civil liberties, since the visibility of its ambitions and scale also made it accountable. Americans are bound to be suspicious of domestic spy agencies that pattern themselves after all-seeing eyes floating disembodied above pyramids, but the Information Awareness Office was comparatively open about its existence and purpose, and it strove to focus its mission in response to oversight concerns (changing the name of its program to Terrorist Information Awareness, for example). In contrast, the Information Sharing Environment has broadened the focus and name of its Common Terrorism Information Sharing Standards to Common Information Sharing Standards.

In one sense, the Information Sharing Environment is a medium tending toward unobstructed transmission; it is like an ocean that conducts whale songs for hundreds of miles. But in another sense, the ISE has created a very private pool of publicly circulating information. Simplified Sign-On, for example, gives those who qualify total access to "sensitive but unclassified" information—but it gives it only to them, and with only internal oversight on how that information is used. The problem is not simply that private information is now semi-public but that the information is invisible to anyone outside organizations that "need to share."

Citron and Pasquale have suggested that if technology is part of the problem, it can also be part of the solution—that network accountability can render total information sharing harmless. Rather than futilely attempting to reinforce the walls that keep information private, publicly regulating how information is used can mitigate the trends that caused the problem in the first place. Immutable audit logs of fusion-center activity would not impede information sharing, but they would make it possible to oversee whom that information was shared with and what was done with it. In fact, it was John Poindexter, the director of the Total Information Awareness program, who first suggested this method of oversight, though even today, many fusion centers have no audit trail at all. Standardization and interoperability might also provide means of regulating what kinds of data could be kept. The technological standards that make information available to users can also facilitate oversight, as Poindexter himself realized.

What sustained the traditional idea of privacy was confidence that some information was private because it was never recorded. That expectation is outmoded. Today, everything may be recorded and then examined for meanings such as subversive intent. Because the era of information scarcity is over, so too is the particular sense of privacy that it sustained. But if we remember that privacy has always been an emerging right—always a declaration of what society found reasonable to expect and could legally enforce—then defending a new kind of privacy becomes a technical problem for technologists and jurists. We must first decide what we want.

Privacy has a surprising resilience: always being killed, it never quite dies. Contemporary information technologies are placing intolerable burdens upon the capacity of individuals and groups to seclude themselves. If privacy is to survive in a new era, we will need new countervailing technologies and new kinds of laws. tr

AARON BADY TEACHES ABOUT PRIVACY, PUBLICITY, AND LITERATURE AT THE UNIVERSITY OF CALIFORNIA, BERKELEY, AND WRITES ABOUT THE SAME ON HIS BLOG, ZUNGUZUGU.

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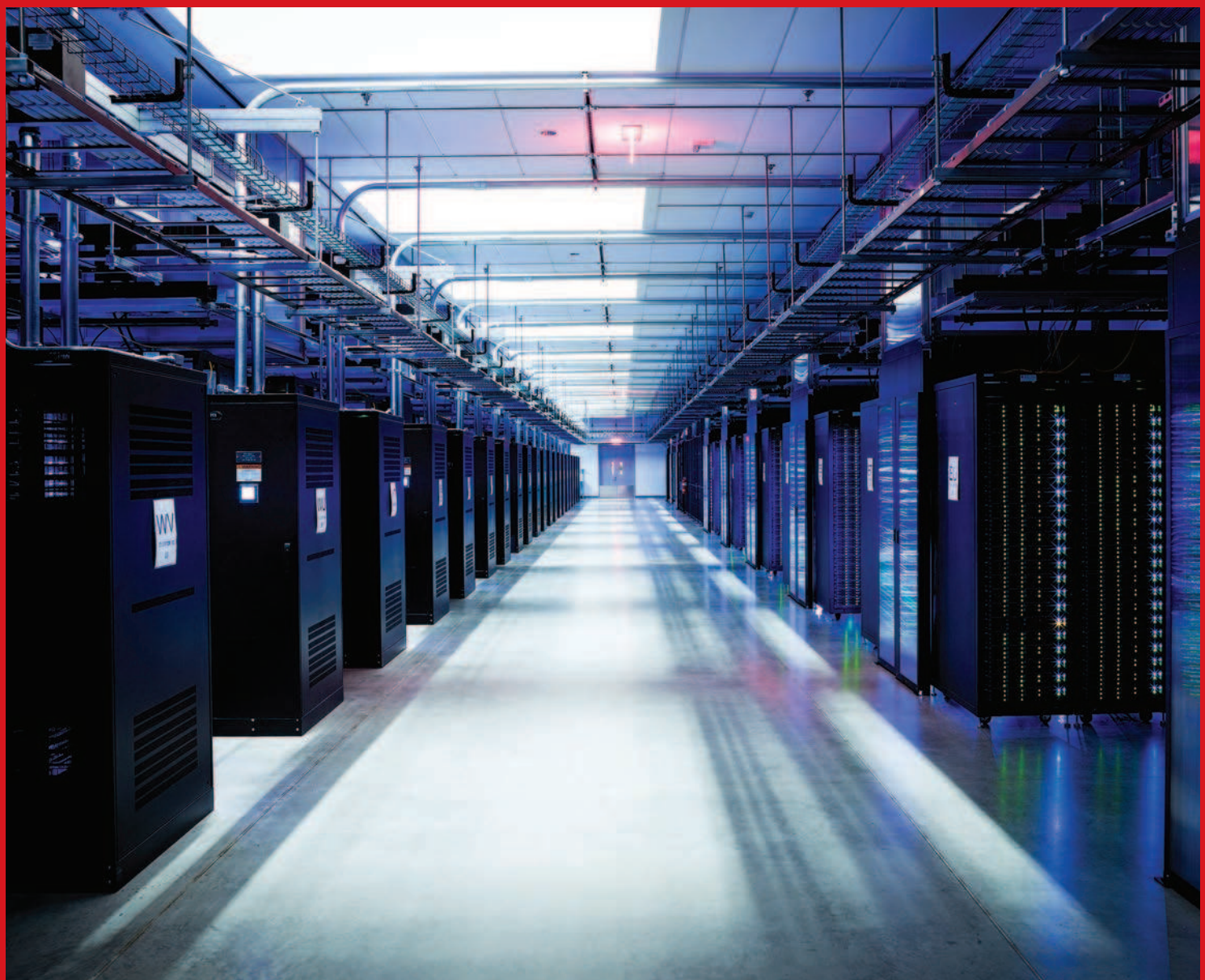
BUSINESS IMPACT

HOW TECHNOLOGY IS CHANGING BUSINESS

Tapping the resources of the "cloud" to treat computing as a utility is overturning the economics of IT. In this issue and online, *Technology Review* explores key questions about cloud computing.



JASON MADARA

Cloud Computing

THE BIG QUESTION

The Cloud Imperative

Treating computing as a utility, like electricity, is an old idea. But now it makes financial sense—a historic shift that is reshaping the IT industry.

By SIMSON L. GARFINKEL

Before Facebook and Google—even before the Internet—scientists at MIT had a radical vision they called the computer utility.

"Computing may someday be organized as a public utility just as the telephone system is a public utility," Professor John McCarthy said at MIT's centennial celebration in 1961. "Each subscriber needs to pay only for the capacity he actually uses, but he has access to all programming languages characteristic of a very large system … Certain subscribers might offer service to other subscribers … The computer utility could become the basis of a new and important industry."

Those words presciently described a phenomenon sweeping the Internet today: cloud computing. Instead of buying their own computer systems, companies, individuals, and even governments can share time on a common computing infrastructure, which consists of interchangeable parts providing computation, data storage, and communications. If one piece malfunctions or needs updating, programs and data automatically move to others. Multilevel security prevents users from interfering with one another. This vast system is cheaper to operate than many individual computers scattered among different businesses and agencies, because both the hardware and the administrative staff can be utilized much more efficiently.

What has changed since McCarthy's time is the advent of advanced "virtualization" systems that can generate just the computing resources needed at any time, letting surplus resources be returned to a general pool. This means that service providers such as Amazon can offer a pay-as-you-go utility billing model to customers on a very large scale. The consequences of this shift are far-reaching: one of the clearest is that today there's very little need for businesses to purchase a computer system other than PCs and laptops for employees. Whether they need a mail server or a rack of computers for a high-performance computing cluster, companies can almost always save money and get better performance by hiring a service in the cloud instead of buying their own.

Google has had a few outages in the cloud, and Amazon had an embarrassing situation in April, when some customers lost service and data. But companies that manage their own data have downtime, too—typically more than a few hours each year.

Consider the economics of handling e-mail in a company. Today the cost of an entry-level Dell server to receive, store, and route the messages is less than $300. But by the time you add Windows Server software to run the machine, a second hard drive for redundancy, Microsoft's Exchange Server 2010 to let an administrator manage the e-mail, and employee licenses of $35, you're up to at least $3,250 for a department with 50 employees. Alternatively, you can have your employees use Microsoft's cloud-based service, Exchange Online, for $10 per user per month, with unlimited storage.

On the surface, a $6,000 annual cloud bill might not seem like the better deal, but doing it yourself carries high hidden costs, from hiring someone to manage e-mail servers to keeping up with security updates to paying air-conditioning bills for your IT room. The cloud service is backed up at multiple locations, and it connects to mobile phones and group calendars. Most important, you can take advantage of the utility model that John McCarthy envisioned in 1961: you purchase only what you need. Microsoft has enough capacity to let you keep adding employees as quickly as you want.

The advantageous economics of the cloud are helping many of today's Web startups get going quickly and without nearly as much capital as they might have required a decade ago. Even so, many established businesses say they are avoiding the cloud because they aren't fully confident of its security and reliability. They can point to high-profile problems: Google has had a few Google Docs outages, and Amazon had an embarrassing situation in April, when some customers lost service and data.

But companies that manage their own data have downtime, too—typically more than a few hours each year. What's more, Google and Amazon responded to these outages as only publicly traded companies would: they issued detailed reports on what happened, how big the problem was, and what they were doing to prevent it from happening again. When was the last time you got a detailed report from your IT group because you couldn't read your e-mail?

The fact is, many companies are uncomfortable giving up control. In a March study of IT managers, sponsored by the computer reseller CDW, one curious result was that most respondents said their preferred way to use the cloud would be to have a pri-

vate one. Private clouds feel the same to end users but are run by the companies themselves, not by a third party such as Amazon. Building a private cloud is no small undertaking, however. Private clouds need to have all the capabilities of cloud systems—virtual computing infrastructure, data centers with redundant cooling and power, off-site backup, etc.—but the costs are borne by a single organization, without the best benefit of the cloud: the utility pricing. As CDW points out in its analysis, running a private cloud means essentially "becoming a cloud hosting provider," except you never recoup costs by selling your product. Private clouds might make sense only for organizations that have hundreds of thousands of employees or data so sensitive—such as military information or the financial transactions of a Swiss bank—that it can never be allowed near the public Internet.

One of the few areas where cloud-based offerings are not vastly superior to the systems they replace is desktop productivity apps—word processing, spreadsheets, presentation software, and calendars. Yes, Google and Microsoft both offer cloud-based office applications. But the desktop versions are still faster, more flexible, and easier to use. What's more, you can put 10 years' worth of documents on your laptop and edit them on a cruise, on an airplane, or in one of the few remaining coffee shops that lack a decent Internet connection. But laptops get lost, stolen, and dropped in swimming pools, so be sure to encrypt the files on that laptop—and you should probably back them up to the cloud.

The facts are really simple: although all organizations on the Internet essentially are using some cloud-based services, they should use more. The economies of scale are becoming mind-blowing. Someone who wants to go buy a rack of servers probably hasn't done the math. BI

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MARCO GARCIA

DATA DETECTIVE
Security expert Jeremiah Grossman says fears about cloud computing are overblown.

LEADERS

Being Smart about Cloud Security

An authority on Web security believes data might be safer in the cloud.

For many companies, cloud computing sounds like risky business. They worry that storing customer details or running critical software on the servers of a cloud provider such as Amazon or Google could make their data more vulnerable to being hacked, exposed, or lost. A lot of data in the cloud resides on shared servers where only virtual walls might separate one company's bits from those of its competitors.

Yet such fears are misplaced, says Jeremiah Grossman, founder of WhiteHat Security, which advises companies such as credit rater Fair Isaac on their Web security. Grossman, a former information security officer for Yahoo, offered some advice about the cloud in an interview with *Technology Review*'s deputy editor, Brian Bergstein.

***TR:* Why do you think there are security advantages in going to the cloud?**

Grossman: The average enterprise, whether you're talking small, medium, or the largest of the large—they're in their respective businesses. A bank isn't in the business of technology. A retailer isn't in the business of managing IT infrastructure. A service provider like an Amazon, they have very particular skills [at] making really secure infrastructures. What you get from a cloud provider is economies of scale—and somebody else to manage the problem.

This is the most ingenious hacker attack on the cloud that I've heard of: someone hires a cloud provider to run a Web application on a shared server and then "bursts the cloud" to infect other users of

the same machine. Is this merely a theoretical attack, or has it been done?

It's theoretical in the sense that we've never heard of it being done in the wild. We have seen different types of attacks in which it's possible to break out of the virtualized containers [in which each cloud client's data resides]. They're quickly patched, but it is entirely possible. It is probably not a likely attack, because there are vectors that are way easier to do. But you should assume that the separation between clients is going to break down. You're going to want to be resilient under those scenarios, [in part by setting rules about encrypting data and] who can get access to it.

Then what's your worst-case scenario for organizations that shift to the cloud?

From a business standpoint, if you're running the system yourself, you have a notion of resiliency, meaning—in the event of a catastrophe, whether a natural disaster or a business bankruptcy—you kind of have control of the infrastructure. You don't have a lot of control when it comes to the cloud providers should they go out of business, should they be acquired by your nearest competitor. All of a sudden your cloud provider, which your business depends on, evaporates and goes away. What's your contingency plan? That's a major consideration.

Some CIOs are likely to run aspects of their websites in the cloud but retain control of some key applications. Is there a security issue raised in the handoff between a cloud service and someone's on-premises systems?

That's actually how it's going to be for the vast majority of businesses out there: "I'm going to host my own website, but all my payments are going to run through a third party." There's a lot of benefit to doing that, but there's also complexity to the situation. Complexity tends to be the enemy of security. The more complex you make your data flow—the more complex you make the systems and all the interconnects—the more difficult it is to manage it, understand it, and mitigate all the threats. BI

LOOK INSIDE
An employee shows one of Facebook's custom-designed servers.

JASON MADARA

EMERGED TECHNOLOGIES

Facebook Shares Its Cloud Designs

Cloud hardware could get cheaper because of the social network's self-interested altruism.

By TOM SIMONITE

If you invented something more efficient and more powerful than what came before, you might want to guard the recipe. Yet Facebook took the opposite approach after opening a 147,000-square-foot computing center in rural Oregon this April. It published blueprints for everything from the power supplies of its computers to the cooling system of the building. Other companies are now cherry-picking ideas from those designs to cut the costs of building similar facilities for cloud computing.

The Open Compute Project, as the effort to open-source the technology in Facebook's vast data center is known, may sound altruistic. But it is an attempt to manipulate the market for large-scale computing infrastructure in Facebook's favor. The company hopes to encourage hardware suppliers to adopt its designs widely, which could in turn drive down the cost of the server computers that deal with the growing mountain of photos and messages posted by its 750 million users. Just six months after the project's debut, there are signs that the strategy is working and that it will lower the costs of building—and hence using—cloud computing infrastructure for other businesses, too.

Facebook's peers, such as Google and Amazon, maintain a tight silence about how they built the infrastructure that underpins their businesses. But that stifles the flow of ideas needed to make cloud technology better, says Frank Frankovsky, Facebook's director of technical operations. He's working to encourage other companies to contribute improvements to Facebook's designs.

Among the partners: chip makers Intel and AMD, which helped Facebook's engineers tweak the design of the custom motherboards in its servers to get the best computing performance for the least electrical power use. Chinese Web giants Tencent and Baidu are also involved; after

touring Facebook's Oregon facility, Tencent's engineers shared ideas about how to distribute power in a data center more efficiently. Even Apple, which recently launched its iCloud service, is testing servers based on Facebook's designs.

The project is especially timely for server makers such as Hewlett-Packard and Dell, which face a threat as business customers stop buying their own servers and instead turn to huge third-party cloud operations like those offered by Amazon. "IT purchasing power is being consolidated into a smaller number of very large data centers," Frankovsky says. "The product plans and road maps of suppliers haven't been aligned with that." Studying the designs of one of the biggest cloud operators can help suppliers reshape their product lines for the cloud era.

However, not everyone wants servers to run just like Facebook's, which are designed for the demands of a giant online social network. That's why Nebula, which offers a cloud computing platform derived from one developed at NASA, is tweaking Facebook's designs and contributing them back to the Open Compute project. Nebula CEO Chris Kemp says this will help companies that need greater memory and computing resources, such as biotech companies running simulations of drug mechanisms.

Larry Augustin, CEO of SugarCRM, which sells open-source cloud software to help businesses manage customer relations, sees challenges for Open Compute. "There have always been efforts on open hardware, but it is much harder to collaborate and share ideas than with open software," he says. Nevertheless, Augustin expects the era of super-secret data center technology to eventually fade, because the secrecy is a distraction for businesses. "Many Internet companies today think that the way they run a data center is what differentiates them, but it is not," he says. "Facebook has realized that opening up will drive down data centers' costs so they can focus on their product, which is what really sets them apart." BI

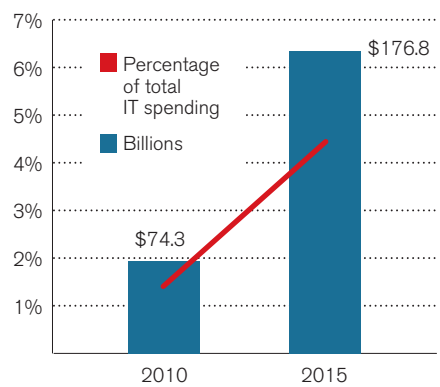
INFOGRAPHICS

Business Gets Remote

Cloud computing is redefining the way companies send e-mail, store data, and allocate IT budgets.

The amount of IT spending on cloud computing services, such as data storage, is small but growing.

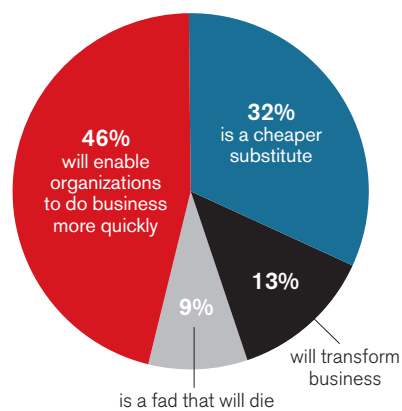
Global spending on public cloud services



Source: Gartner

Most companies seek efficiency; some see cloud computing as a transformational force for business.

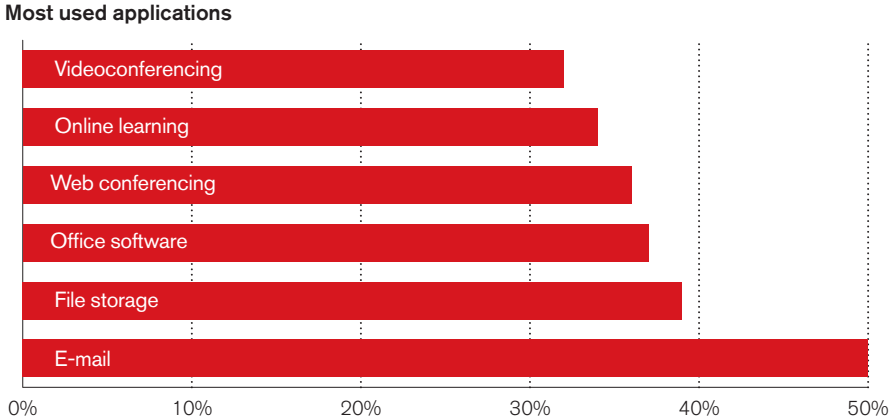
In your opinion, cloud computing ...



Source: Accenture survey of 669 IT decision makers

Most companies that shift processes to the cloud begin with commodity applications.

Most used applications



Source: CDW poll of 320 corporate cloud users

Cloud computing will mean more servers and data storage—but not many more IT jobs.

Expected growth in the next 10 years

10x
The number of real and virtual servers worldwide

50x
The number of bytes managed by enterprise data centers

1.5x
The number of IT professionals in the world

Source: IDC

CASE STUDIES

Transcending Borders but Not Laws

As cloud computing spreads data around the globe, a haze of legal and privacy questions follows.

By ERICA NAONE

There's a problem facing cloud computing that doesn't have an easy solution yet.

Although it is often not obvious where data is actually residing when it's uploaded to a cloud service such as Web-based e-mail, the location does matter. And depending on the legal jurisdiction where the data is stored, it could be exposed to government scrutiny or to unexpected regulations. "When data is physically located within a country, that country has the practical ability to force access to that data by various means," says Katitza Rodriguez, international rights director for the Electronic Frontier Foundation, a tech-focused civil-rights organization.

That is cause for worry in Canada and some European countries, where activists fear that strict local privacy rules may not apply if citizens' data is stored on servers in the United States. The powers of U.S. law enforcement to snoop on e-mail and other records were expanded by the USA Patriot Act, passed shortly after the September 11 terrorist attacks. The Canadian province of British Columbia responded with a 2004 law requiring public bodies to ensure that citizens' personal information, such as health records, be "stored only in Canada and accessed only in Canada."

The spread of restrictive data laws could make it more difficult for overseas companies and government agencies to use commercial cloud providers, the largest of which are based in the United States. Indeed, the U.S. Department of Commerce considers legal obstacles to "transborder data flows" a brewing threat to free trade. It has formed a committee with Mexico and Canada to make sure privacy laws don't stand in the way.

The jurisdictional issue is already having effects. Francis deSouza, group president for enterprise products and services at Symantec, says his company has negotiated with a Swiss financial institution about running the bank's e-mail servers and other software. In principle, they could be hosted in an existing Symantec data center anywhere. But because Swiss bank secrecy laws don't apply outside the country, deSouza says, doing business will mean building a new data center in Switzerland.

Yet storing data outside the U.S. may not be enough to shield it from American law enforcement. Microsoft and Google inflamed anxieties in Europe this summer when they confirmed that even data stored outside the United States—including in European data centers—could be subject to lawful U.S. government requests (not to mention those of other nations). All this is making the cloud a difficult place to hide, particularly when it comes to sensitive data. Last year, for instance, Amazon booted the whistleblower organization WikiLeaks off its cloud servers amid complaints from Washington that WikiLeaks was storing stolen classified documents on the machines.

Another potential headache: some countries require data to be logged for a certain amount of time, while others require that data be deleted after a certain time. As a result, companies like Facebook that store data in multiple places may face conflicting mandates, says Daniel Garrie, general counsel for the Focused Solution Resource Delivery Group, which advises companies on cloud computing contracts. BI

More on Cloud Computing

Read the complete report at **technologyreview.com/business/cloud**

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China thinks big—very big—when it comes to cloud computing.

Chasing the African Cloud
The developing world demands its own data centers.

Online Storage: The Route to Ruling the Cloud?
Two startups that ease file-sharing hope to become Internet giants.

Who Coined "Cloud Computing"?
A tale of a buzzword and a failed business.

5 Ideas for Using Server Waste Heat
Innovative ways to make data centers more efficient.

Q&A with Marc Benioff
The Salesforce.com founder helped pioneer cloud services.

The Virtual HR Department
How cloud computing can change workforce management.

PUBLISHING

A New Chapter for E-Books

Lavish electronic-book projects point toward the pinnacle of the medium.

By ERICA NAONE

The problem with the Harry Potter series, for me and many others, was that it had to end. For fans used to midnight book-launch parties and concerts by bands with names like Draco and the Malfoys, the 2007 release of author J. K. Rowling's seventh book closed out an era. But starting this past summer on Harry Potter's birthday—July 31—Rowling offered fans the chance to bring Harry Potter to new life by hunting the "Magical Quill" online.

Harry Potter fans are notoriously hungry for information related to the green-eyed boy wizard, but this wasn't just a marketing stunt offering up a few scraps. The quill gave the bearer early access to the new website Pottermore, where Rowling has hired a team to create a new way to read her books. The site has exclusive rights to sell digital audio and e-book editions of the Harry Potter series—Rowling has never before licensed her work for such formats—but it's also seeded with 18,000 previously unreleased words of Rowling's Potter-related writing, with more to come. Over time, the site will weave the books together with interactive and social features that allow readers to connect with one another and with the characters in Rowling's world.

Pottermore
www.pottermore.com

Principles of Biology
$49
Nature Education, 2012

"In making e-books available, we wanted to provide something special for readers—not just something that was a reprise of what had taken place in print form," says Rod Henwood, interim CEO of the Pottermore company, which Rowling established to maintain the site.

Rowling's effort points the way toward a social, deeply interconnected, digital experience of reading a book—a book that is designed to change over time. Not all authors will have the resources and readership to produce a project like Pottermore. Nonetheless, the website presages a new kind of reading experience, one that takes greater advantage of the electronic aspect of e-books.

There's much to be dissatisfied with in today's typical experience of e-books. They lack the sensual attributes of books—including the paper quality that signals the difference between an elegant literary edition and a cheap, pulpy paperback. But I'm not just lamenting the vanishing joys of print. As a vision for the future, today's e-books are far too conservative—they miss many opportunities.

I'm also not advocating a return to the distracting bells and whistles that characterized the CD-ROM books of decades past, or suggesting the revival of hypertext literature. What I do want is for e-books to reflect the immediacy and responsiveness of today's Internet. A truly electronic book should allow me, with just a few clicks, to jump through every dream sequence in a work of fiction or follow supporting lines of argument threaded through a work of

CHAMBER OF SECRETS Pottermore gives readers ways to get involved with the Harry Potter stories—interactions that can lead them into additional text by J.K. Rowling.

nonfiction. And a book in electronic form doesn't have to be a static snapshot. It can and should grow and change.

Rowling's Pottermore could be such an effort. The site is organized around "moments"—key points in the Harry Potter stories. For each moment, Pottermore features a lavishly illustrated interactive scene, where users can choose to linger or not. Exploring the scene provides a chance to find new snippets of Rowling's writing, such as expanded back stories for characters. The moments interface tracks characters, places, and objects that appear in the stories—all of them, not just the major ones—and presents information about them in one place, with pointers to the stories themselves. Users can put their favorites on their profiles, discuss them with the site's community, or upload their own art.

Crucially, this interactivity isn't just filigree on the Pottermore website that remains separate from the books themselves. When I read the seven books, I was taken with the Sorting Hat, a magical hat that detects deep currents in the wearer's personality and determines which house at the wizarding school would best suit him or her. People reading a Potter e-book through Pottermore can get their own house assignments from the hat at the same time Harry gets his. The readers' assignments affect their later interactions on Pottermore—and expose them to bonus material, written by Rowling, about their house.

No matter how impressive Pottermore ends up being, it's still pulling a print work into an electronic format. Next year, Nature Education will release a more comprehensive attempt to rethink the electronic book, a $49 textbook called *Principles of Biology*. It results from the vision of Vikram Savkar, senior vice president and publishing director of Nature Publishing Group, who was responsible for launching the company's education arm in 2007.

Students don't buy a copy of the book—they buy lifetime access. The plan is for the textbook to serve not only as a reference for the class but as a pointer to further knowledge. Instead of publishing revised editions, Savkar's team will keep the book up to date.

Principles of Biology is written as a series of more than 200 self-contained modules; the publisher has suggested an order for the modules, but instructors who use the book in their classes can freely drop or shuffle them. Instructors can also choose settings that increase or decrease the difficulty of the material. *Principles of Biology* connects related modules, and with just a click, students can access journal articles, summaries of those articles, and online resources that weren't produced by Nature.

To make this possible, Savkar's team shied away from creating the sort of e-book familiar to users of the Kindle or iPad. Like Pottermore, *Principles of Biology* is fundamentally a website, built in part with a developing technology called HTML5 that's designed for interactivity and can appear on any device with a Web browser. (*Principles* also uses Flash, so it can be read in browsers that don't yet support HTML5.) Savkar says that tying the book to the Internet itself, rather than creating specific apps or versions for specific devices, is the only way to keep the development cost down over time while ensuring that students can access the book from anywhere.

Even with that approach, none of this comes easily or cheaply. Henwood says the team that became Pottermore started working on digital experiences for Rowling's series even before the iPad was launched, and the e-book content was recently delayed until early 2012. Nature's process is also slow—Savkar expects that it will take his team at least a year to build its next digital textbook. The economics of publishing are such that few books will be able to get the painstaking, hand-designed development that went into Pottermore and *Principles of Biology*. Both have potential life spans of decades rather than weeks or months, giving their creators a financial incentive to develop their time-consuming vision.

But these teams' ideas will eventually be copied and modified in ways that are increasingly easy for other publishers to reproduce. That will slowly define new expectations for what an electronic reading experience can be, even in less lavish works. Already, for instance, with its latest Kindles, Amazon is working toward automatically adding links and social experiences to the majority of books, doing textual analysis to come up with relevant Wikipedia articles and other supplementary material from the Internet, and providing ways for people to learn which passages most readers have found interesting. These features could eventually yield the sort of immediate document that makes an e-book truly worthy of the name. tr

ERICA NAONE IS WEB AND SOCIAL NETWORKING EDITOR AT *TECHNOLOGY REVIEW*.

POTTERMORE

SCIENTIFIC ETHICS

Public Mea Culpas

Scientists and the journals that publish them have a difficult time admitting to mistakes. That does real harm to both their disciplines and the public.

By JON COHEN

Earlier this year, the *Journal of Biological Chemistry* retracted four papers by the same researcher, who studies immune-system chemicals that have links to cancer and autoimmune diseases. In each case, the journal offered an identical explanation: "This article has been withdrawn by the authors." As Ivan Oransky wrote in Retraction Watch, a blog that started in August 2010, "That certainly clears things right up."

Oransky and Adam Marcus, who works with him to highlight errors in scientific publications, are leading a growing group of critics who say that acknowledging these types of mistakes and explaining them matters greatly, especially given the scientific tradition of building arguments by citing the work of others. They contend that for biomedical research in particular, recognizing mistakes can truly be a matter of life and death.

Marcus, a science writer and managing editor of *Anesthesiology News*, and Oransky, a doctor who is also executive editor of Reuters Health, take pleasure in skewering scientific behavior that ranges from clumsy and preposterous to devious and downright criminal. In their first post, they explained that retractions cover a wide range: they may reflect an honest mistake in the research, or they can address full-blown fraud. But the bulk of retractions involve errors that are somewhere between the extremes, and they argue, convincingly, that most "live in obscurity in Medline and other databases." Many journals have no retraction policies, and the ones that do often publish these critical notices of error long after the original paper appeared.

The current record holder, a German anesthesiologist named Joachim Boldt, had more than 80 papers retracted by editors of 18 different journals because he had failed to receive approval from an institutional review board before conducting human studies. Boldt was relieved of his duties as chief physician at Ludwigshafen Hospital in Rhineland after separate allegations that he published a study based on a drug trial that never took place. Former Duke University oncologist Anil Potti, who falsely claimed on grant applications to have won a Rhodes scholarship, had seven papers retracted because his group could not reproduce its own work.

Analyses show that retractions have skyrocketed over the past decade. Neil Saunders, a statistical bioinformatician for the national science agency in Australia, has created a Web application that tracks retractions in the main database of biomedical publications, PubMed. Since 1977, the number of publications has jumped almost fourfold, but the number of retractions has increased by a factor of about 30. This could reflect an increase in self-policing or fraud, a growing public consciousness, the effects of social networking, the use of plagiarism-detecting software, or a combination of these factors. Even reading the full notice, as Retraction Watch makes abundantly clear, often does not yield any meaningful understanding of why the retraction occurred.

The opacity of the *Journal of Biological Chemistry* has had some serious competition. In 2009 the *Journal of the American Chemical Society* retracted a paper with this ridiculous note: "This manuscript has been withdrawn for scientific reasons." When Adam Marcus phoned the *Annals of Thoracic Surgery* for more information about a vaguely worded retraction, the editor, L. Henry Edmunds Jr., responded: "That's none of your damn business."

Actually, it is our business: the public funds a great deal of scientific work. What's more, errors can cause real harm. An article published online May 17 in the *Journal of Medical Ethics* examined 180 retracted papers published between 2000 and 2010. Author R. Grant Steen, a biologist who runs a medical communications consulting business in Chapel Hill, North Carolina, found that these erroneous papers had involved 9,189 patients who received a treatment. The retracted studies were cited more than 5,000 times, more than one-third of them after the retractions—and those subsequent studies involved 70,501 treated patients. The paper detailed specific harm that might have occurred as a result, including undermedication of patients who had postsurgical pain, unnecessary surgery for cancer patients, and a treatment for kidney disease that may have made patients' outcomes worse.

In a separate survey that Steen published in the same journal, he analyzed the reasons

behind the retractions of 742 papers during the preceding decade. Nearly 75 percent resulted from errors including scientific mistakes, ethical issues, and plagiarism, while the rest were due to either data fabrication or falsification—that is, fraud. Steen's analysis revealed that the incidence of retraction for both error and fraud has increased steeply: the number of papers retracted as fraudulent jumped from two in 2000 to 51 in 2009, and the number withdrawn annually for scientific mistakes rose from one to 35 over the same period. Steen suggests that the increases may reflect a more aggressive attempt by journals to police themselves.

Maybe.

Journals certainly are not aggressive about stating their retraction policies. A study published in 2004 by the *Journal of the Medical Library Association* evaluated whether 122 "major" biomedical journals even had such policies. Michel C. Atlas, a reference librarian at the University of Louisville in Kentucky, first looked to see whether a journal had a retraction policy in its online instructions to authors. Only four did. Atlas e-mailed the editors of the remaining journals and asked for a copy of their policy, if any. In the final tally, 76 of the editors—78 percent of those who responded—reported that their journals had no formal policy.

Not having a policy does not, of course, equal a reckless disregard for the truth. Some said they adhered to standard guidelines. And some journals defend not having a hard-and-fast policy because retractions are often complicated.

Take *Science*, where I am a contributing correspondent. I recently interviewed Bruce Alberts, the editor in chief, about a paper the journal published in 2009. The study linked a mouse retrovirus to chronic fatigue syndrome. At the time I spoke with Alberts, a dozen independent groups had reported that they could not replicate the work, and suspicions were mounting that the samples had been contaminated. Although no evidence then existed of contamination or error in any of the contributing authors' labs, Alberts had asked the authors whether they wanted to retract. Several were incensed, and all felt a retraction was premature. Alberts settled for publishing an "editorial expression of concern."

I asked Alberts where he drew the line between requesting a retraction and letting the study languish in disgrace. "It's always tough," he said. In the absence of outright fraud, plagiarism, or blatant error, editors have to make difficult judgment calls about a decision that can bring both promising lines of research and ascending careers crashing down. *Science*, in a further layer of nuance and complexity, later ran an unusual "partial retraction" after one of the labs that contributed to the paper found contamination.

Given that the evidence suggests most retractions do not stem from the manipulation of data, the reluctance to come clean seems self-defeating. The culture of science affords a great deal of respect for those who show flexibility in response to facts, even if it means spotlighting their own shortcomings and previous errors. Mistakes are particularly easy to make in the type of high-risk science that breaks new ground, and scientists should be encouraged to take such risks. But scientific journals need to be far more forthcoming in addressing those errors with full explanations, and in acknowledging that promptly retracting results is also part of the communication process. tr

Retraction Watch
retractionwatch.wordpress.com

Retractions in the Medical Literature: How Many Patients Are Put at Risk by Flawed Research?
R. Grant Steen
Journal of Medical Ethics online, May 17, 2011

Retractions in the Scientific Literature: Is the Incidence of Research Fraud Increasing?
R. Grant Steen
Journal of Medical Ethics 37(4): 249–253

Retraction Policies of High-Impact Biomedical Journals
Michel C. Atlas
Journal of the Medical Library Association 92(2): 242–250

Editorial Expression of Concern
Bruce Alberts
Science 333(6038): 35

JON COHEN, A CORRESPONDENT WITH *SCIENCE*, HAS WRITTEN FOR THE *NEW YORKER*, THE *ATLANTIC MONTHLY*, AND THE *NEW YORK TIMES MAGAZINE*. HIS LATEST BOOK, *ALMOST CHIMPANZEE*, WAS PUBLISHED LAST YEAR.

SHOW OF FORCE A Pershing missile was paraded through Washington, D.C., for the inauguration of President John F. Kennedy in 1961.

ASSOCIATED PRESS

POLICY

Rethinking the Unthinkable

Nuclear proliferation in the 21st century should force the United States to reconsider whether the principle of deterrence actually promotes stability and peace.

By MARK WILLIAMS

In the days when the Soviet Union stretched across 11 time zones and the Strategic Defense Initiative wasn't yet a twinkle in the eye of a just-elected President Ronald Reagan, a political scientist named Kenneth Waltz provoked nuclear hawks and doves alike by publishing an article called "The Spread of Nuclear Weapons: More May Be Better."

Waltz, a founder of the so-called "structural realism" or "neorealist" school in international-relations theory, argued that if peace is defined as "the absence of general war among the major states," an unprecedented era of peace had prevailed since the Hiroshima and Nagasaki bombings in 1945. It would be nice, he continued, if nations possessed only conventional weapons and never fought. But given that they do come into conflict and that "ten or twelve or eighteen nuclear-weapon states" would probably exist someday—there were seven in 1981, when he wrote, and now there are nine—"the gradual spread of nuclear weapons is better than no spread and better than rapid spread."

By favoring "gradual" spread, Waltz stopped his argument short of its reductio ad absurdum, which would be that because nuclear states have strong incentives to avoid wars with each other, the world automatically becomes that much safer whenever another nation acquires thermonuclear weapons. And by maintaining that a gradual spread was better than none, he avoided the logical inconsistency of conventional deterrence theorists who believe that proliferation should be prevented.

Today Waltz and other neorealists continue to argue that states would do whatever served their self-interests but for those constraints imposed by the international balance of power. When nuclear weapons enter the picture, the neorealists contend, the costs of waging war exceed the bearable (or even the survivable), making a balance of power based on nuclear deterrence inherently and uniquely stable.

Whether one thinks that Waltz's argument is crazy or makes sense, advancing technology is creating increasingly propitious conditions for it to be tested. Outside Wilmington, North Carolina, for example, is an unexceptional building that in 2012 or 2013 will probably become the world's first commercial plant for uranium enrichment by LIS, or laser isotope separation. LIS at the proposed facility promises to produce reactor-grade uranium, in which the concentration of fissile uranium-235 has been increased from its natural levels to as much as 8 percent, at radically lower cost and with less waste than the current techniques based on diffusion or centrifuge technologies. Charles D. Ferguson, president of the Federation of American Scientists, notes that if this particular process works as advertised, "not only will LIS be a far more efficient method, it'll also be far more difficult for outsiders to detect."

Nowadays, when experts like Ferguson are asked what the surest route would be for nations to covertly produce weapons-grade fissile material—usually defined as highly enriched uranium with a U-235 content of at least 90 percent—they point to LIS. The technology someday could even be within reach of actors that are not nation-states. Potentially requiring only a midsize warehouse and drawing no more electricity than a dozen suburban homes, an LIS plant might operate unnoticed almost anywhere. The Lashkar Ab'ad laboratory, 40 kilometers west of Tehran, went undetected as Iran's pilot LIS site from 2000 until 2003, when Iranian dissidents revealed its existence to the International Atomic Energy Agency. The IAEA's investigators subsequently concluded that highly enriched uranium could have been produced at Lashkar Ab'ad if all the planned equip-

ment had been installed. Today, according to the dissidents, the Tehran regime's LIS research continues elsewhere; not incidentally, Fereydoon Abbasi Davani, a survivor of the recent spate of car bombings targeting Iranian scientists allegedly involved in Tehran's bomb program, is an expert on the technology.

LIS is just the front end of the trend. In the United States, after canceling plans to use Yucca Mountain as the national nuclear waste repository, the Obama administration established its Blue Ribbon Commission on America's Nuclear Future. Per Peterson, the only nuclear engineer on that commission, has long proposed that the United States do what other nuclear nations do: recycle its spent nuclear fuel. Various reactor designs could make it possible within two to three decades for waste to be burned down to the point of harmlessness. The problem is that such advances would also make it quicker and easier to produce the material needed for nuclear weapons. That could put us at the dawn of the golden age of nuclear arms proliferation.

The Myth of Nuclear Deterrence
Ward Wilson
The Nonproliferation Review, 2008

Essentials of Post–Cold War Deterrence
United States Strategic Command (1995)
www.nukestrat.com/us/stratcom/SAGessentials.PDF

Nuclear Weapons: Stability of Terror
Kyungkook Kang and Jacek Kugler
a chapter in *Debating a Post-American World: What Lies Ahead?*
Routledge, 2011

FAILURES OF DETERRENCE

The Global Zero movement, whose membership includes such former heads of state as Mikhail Gorbachev and Jimmy Carter, thinks a world with nukes in the hands of, say, Myanmar and Syria (to name two regimes that might aspire to nuclear status) would be a far more unstable place. It wants all nuclear arms banned by 2030. So do former U.S. secretaries of state Henry Kissinger and George Schultz, former U.S. secretary of defense William Perry, and former U.S. senator Sam Nunn, who, together, kick-started the Global Zero movement in 2007 by proposing a phased elimination of the world's nuclear arsenals. As someone responsible for the decision to put multiple warheads on U.S. ICBMs in the early 1970s, Kissinger is an interesting apostate against the doctrine of nuclear deterrence. Still, he's long been mindful of the possibility that deterrence is ineffective or unnecessary. As he wrote in *Diplomacy*, his 1994 magnum opus, "Deterrence can only be tested negatively, by events that do *not* take place, and … it is never possible to demonstrate why something has not occurred … or whether the adversary ever intended to attack in the first place."

Now, one would expect the most destructive of all weapons to have *some* deterrent capability, and on that count the historical record is persuasive. Between 1940 and 1996, the United States built more than 70,000 fission and fusion bombs. The USSR amassed a similar arsenal. And during the almost 50 years that the Cold War lasted, American and Soviet leaderships always arrived—sometimes even as they stated the opposite—at the conclusions that Bernard Brodie, the first American nuclear strategist, reached immediately after Hiroshima and Nagasaki. "Thus far the chief purpose of our military establishment has been to win wars," Brodie wrote in 1946. "From now on its chief purpose must be to avert them."

As Waltz notes, general war among the major states was indeed averted. But Thomas Schelling, one of the principal intellectual architects of U.S. Cold War strategy, argues that this doesn't mean deterrence worked very well. "Since 1945, at least seven or eight wars have occurred, depending on how you count, where one side had nuclear weapons and didn't use them," Schelling says. "Nuclear weapons didn't deter North Korea and China in the 1950s. In 1973, Israel had nuclear weapons it could have delivered against Cairo and Damascus." In his prize-winning essay "The Myth of Nuclear Deterrence" (2008), Ward Wilson, a senior fellow at the James Martin Center for Nonproliferation Studies, in Monterey, California, also cites wars where one side possessed nuclear weapons that failed to deter the other side from aggression. He concludes that "the practical record of nuclear deterrence shows more obvious failures than obvious successes."

Says Jacek Kugler, a professor of world politics at Claremont Graduate University who studied under Brodie and is now a consultant to organizations like the Pentagon and the World Bank, "The critical assumption in Brodie's original model, and in almost every single model of deterrence used today by American policymakers, is that if I simply increase my opponent's cost, I decrease the probability of war." Kugler begs to differ: "To start with, people don't go to war because of the cost. What they calculate is the possibility of gain. So in the 1970s some of us started saying that the conventional theory is nonsense." Kugler believes that dissatisfied or angry challengers could risk a nuclear action—whether a dirty bomb, a limited nuclear attack, or an all-out nuclear exchange—if they believed the conditions were strategically favorable.

Moreover, as Winston Churchill noted when explaining nuclear deterrence to Parliament in 1955, it will never "cover the case of lunatics or dictators in the mood of Hitler when he found himself in his final dugout." A regime facing its own demise has passed beyond worrying about risk. It's perfectly credible that such a regime will employ nuclear weapons, especially if, as North Korea does, it stands at a disadvantage in conventional military terms.

GAME THEORY

The dangers of this dynamic were part of what Schelling had in mind during his Nobel lecture in 2005, when he won the prize in economics for enhancing "our understanding of conflict and coöperation through game-theory analysis." In his lecture, Schelling examined how, over the six decades since Hiroshima and Nagasaki, a nuclear "taboo" had effectively been constructed to prevent such terrible weapons

from being used again. Great diplomatic skill and international coöperation would be necessary to maintain that taboo in a world where, Schelling told his audience, America and other major powers were very likely to experience "what it is like to be the deterred one, not the one doing the deterring."

Such a world, where smaller states acquire nuclear weapons to deter the overwhelming conventional might of the U.S., is not quite the future that the Pentagon's nuclear strategists envisioned after the Cold War. In 1995, the United States Strategic Command (Stratcom) produced a document called "Essentials of Post–Cold War Deterrence," which would be largely restated in George W. Bush's 2001 Nuclear Posture Review. "Since we believe it is impossible to 'uninvent' nuclear weapons," the Stratcom text declared, they "seem destined to be the centerpiece of U.S. strategic deterrence for the foreseeable future." Before the first Gulf War, the authors noted, President George H. W. Bush had apprised Saddam Hussein that the U.S. would not "tolerate the use of chemical or biological weapons." Though this merely hinted at nuclear retaliation, Iraq didn't (according to the U.S. government) field biochemical weapons in the 1991 conflict. The lesson, they concluded, was that in the post–Cold War era, nukes not only should remain central to U.S. strategy but could become part of "policy enforcement"—in effect, a threat to ensure that when the country chose to fight, it would do so on favorable terms. Adversaries should understand that "our actions would have terrible consequences for them," but the U.S. "should not be very specific."

This was singing straight from the Cold War hymn sheet. During the 1950s, U.S. secretary of state John Foster Dulles had argued that it was rational to "remove the taboo" from nuclear weapons so as to intimidate an adversary into concessions; in the late 1960s, Richard Nixon had explained that enemies should be led to believe that "Nixon is obsessed ... We can't restrain him when he's angry and he has his hand on the nuclear button." These statesmen had echoed theorists like Schelling and Herman Kahn at the RAND Corporation: Schelling, for instance, had noted that in bargaining, uncertain retaliation is more credible and more efficient than certain retaliation. What had changed by 1995 was that the USSR was no longer a limiting counterforce in international affairs. In the new circumstances, the Stratcom authors believed, the deterrent threat of U.S. nuclear weapons could exert even greater sway.

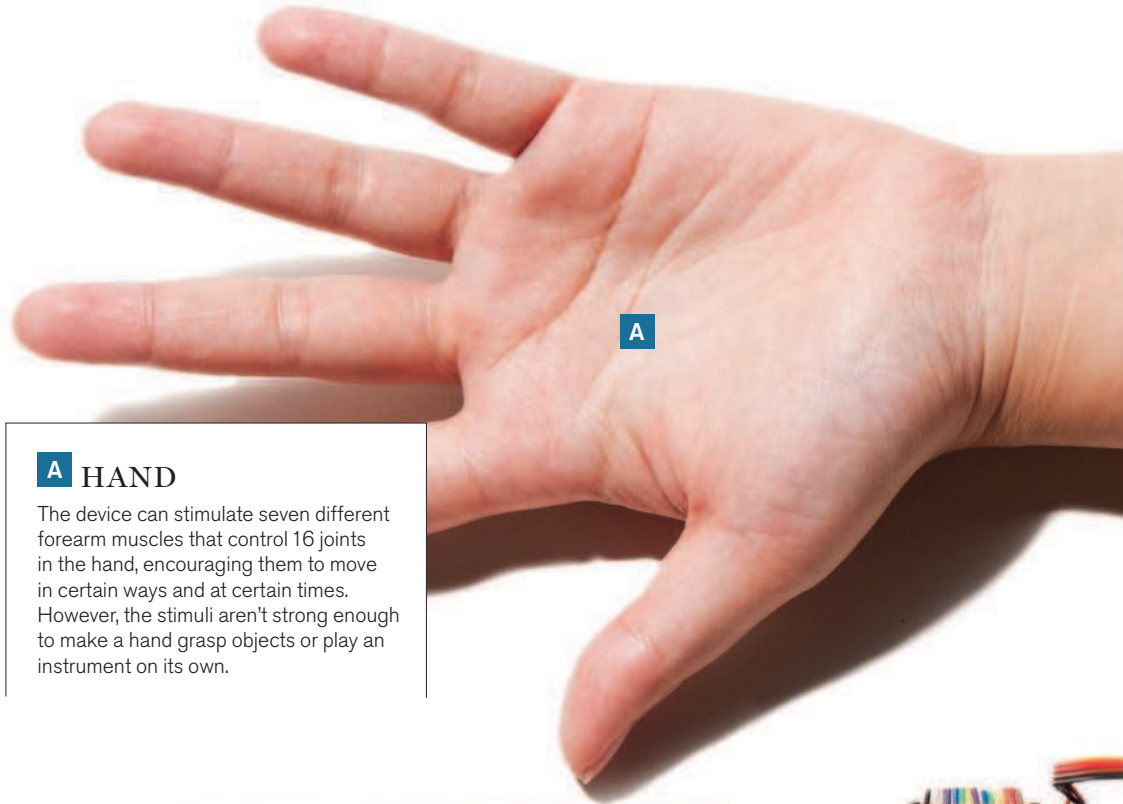
But these planners now seem naïve: a strategy centered on nuclear deterrence has proved worthless against the actual challenges America has confronted. Most notably, on September 11, 2001, its nuclear arsenal had no effect on al Qaeda's calculations.

Furthermore, almost all those Cold War strategists whose ideas were parroted by "Essentials of Post–Cold War Deterrence"—particularly those who approached nuclear deterrence via game theory—would probably have told Stratcom it wouldn't work.

Cold War theories about deterrence were based in part on how two players would behave in any zero-sum game (if one player wins, the other loses), with each player seeking an optimal way to minimize his maximum loss. But in games with more than two players, strategic complexity grows exponentially as the number of players increases. In a multiplayer game of nuclear deterrence, says game theorist Martin Shubik, an economics professor emeritus at Yale, this means escalating instability—even if all actors are assumed to be rational, which does not hold in the age of suicide bombers.

"My main conclusion is that the United States would be strongly advised to call for a global group to supervise all nuclear states and should be the first to open its own facilities so as to get the ball rolling for a worldwide inspection program," Shubik says. "Without something like that, the odds of avoiding a nuclear war in the next 20 years are very low." tr

MARK WILLIAMS IS A CONTRIBUTING EDITOR AT *TR*. HE LAST REVIEWED STEWART BRAND'S *WHOLE EARTH DISCIPLINE* IN MAY/JUNE 2010.



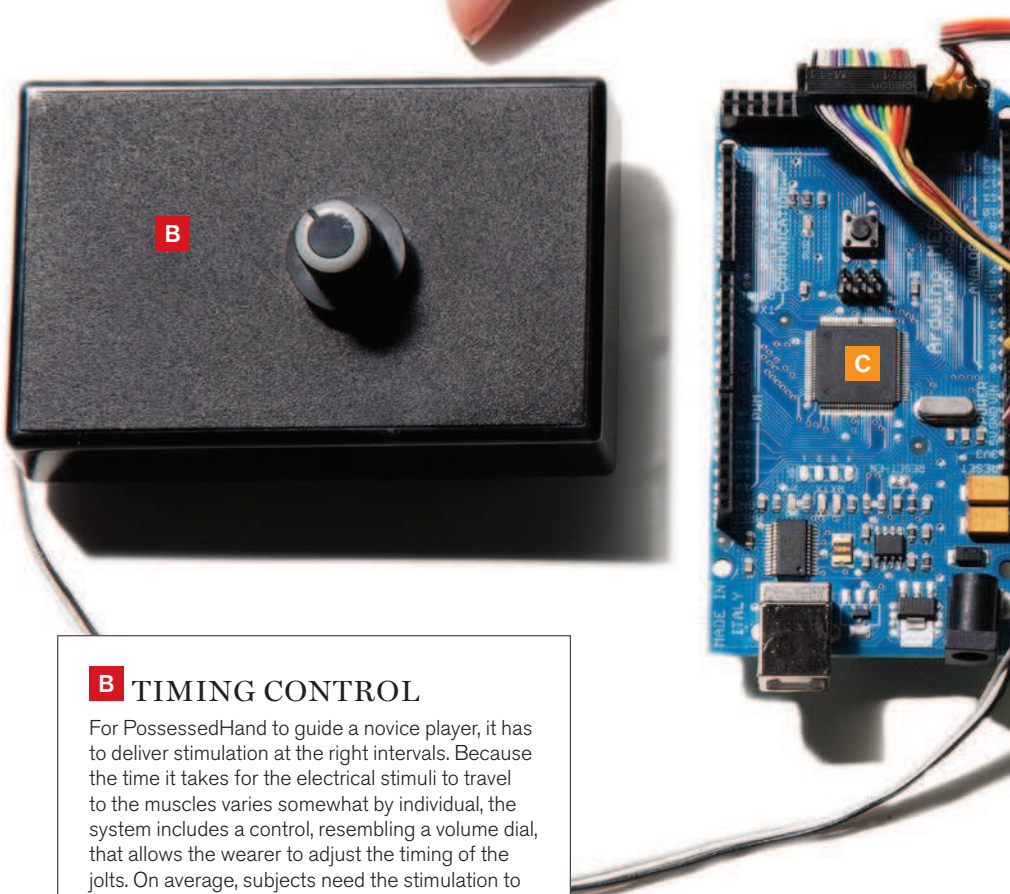
A HAND

The device can stimulate seven different forearm muscles that control 16 joints in the hand, encouraging them to move in certain ways and at certain times. However, the stimuli aren't strong enough to make a hand grasp objects or play an instrument on its own.

Instrument of Control

Belts of electrodes can control muscles in the forearm to help a beginner play a musical instrument.

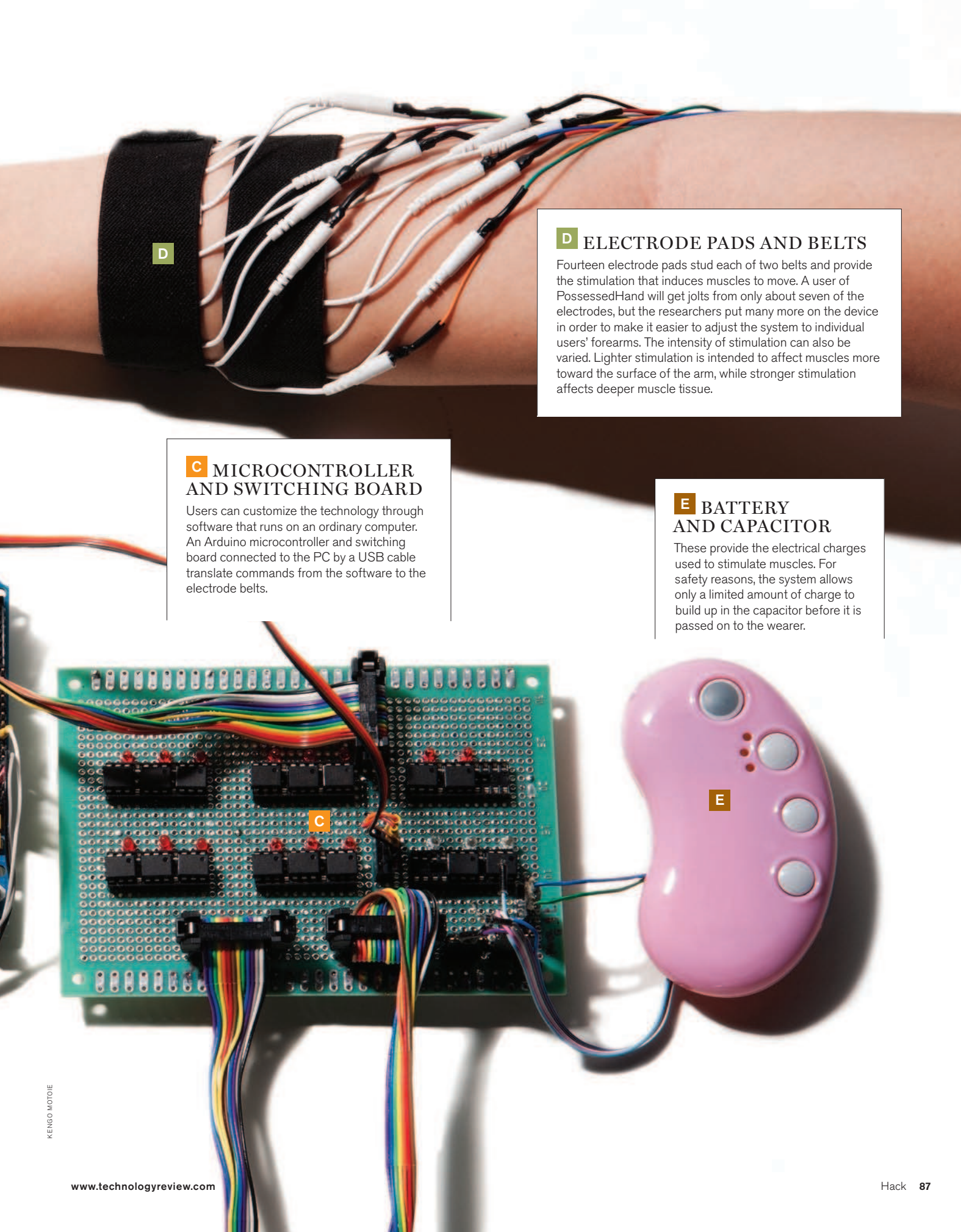
By ERICA NAONE



B TIMING CONTROL

For PossessedHand to guide a novice player, it has to deliver stimulation at the right intervals. Because the time it takes for the electrical stimuli to travel to the muscles varies somewhat by individual, the system includes a control, resembling a volume dial, that allows the wearer to adjust the timing of the jolts. On average, subjects need the stimulation to be activated about 0.34 seconds ahead of when they would play a sound.

RESEARCHERS at the University of Tokyo have built a system they call PossessedHand that electrically stimulates muscles in the forearm at strategic moments to nudge beginners as they play a traditional Japanese instrument called the koto. One of the researchers, Emi Tamaki, says that people who used the technology were much better at playing the proper rhythm and made fewer mistakes. The prototype system is rudimentary and clunky, but its creators believe it could point the way toward machines that help people acquire other skills quickly and easily.



D ELECTRODE PADS AND BELTS

Fourteen electrode pads stud each of two belts and provide the stimulation that induces muscles to move. A user of PossessedHand will get jolts from only about seven of the electrodes, but the researchers put many more on the device in order to make it easier to adjust the system to individual users' forearms. The intensity of stimulation can also be varied. Lighter stimulation is intended to affect muscles more toward the surface of the arm, while stronger stimulation affects deeper muscle tissue.

C MICROCONTROLLER AND SWITCHING BOARD

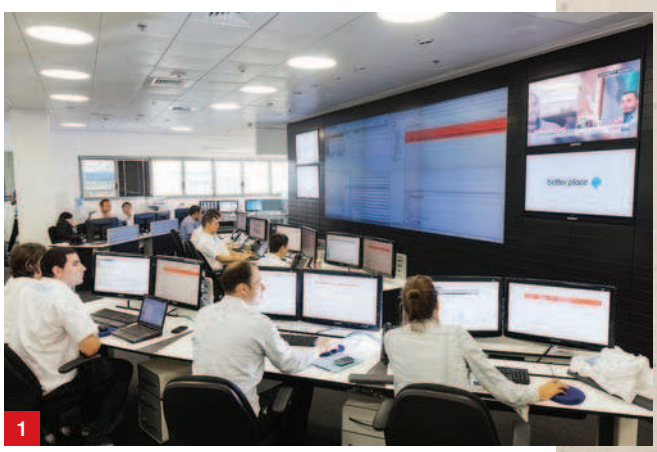
Users can customize the technology through software that runs on an ordinary computer. An Arduino microcontroller and switching board connected to the PC by a USB cable translate commands from the software to the electrode belts.

E BATTERY AND CAPACITOR

These provide the electrical charges used to stimulate muscles. For safety reasons, the system allows only a limited amount of charge to build up in the capacitor before it is passed on to the wearer.

KENGO MOTOJE

demo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1

Battery Fill-Up

Better Place's switching stations allow electric cars to swap batteries during long trips.

By MATTHEW KALMAN

Gal Pearl, a product manager at the Israeli-based company Better Place, disconnects his electric Renault Fluence from a charge point at his company's parking lot in Rosh Ha'Ayin. He enters his next destination into the car's computer—which quickly calculates that the 70-mile journey is longer than his battery's charge level will allow. The computer maps out a route that passes a battery switching station operated by Better Place. There, an industrial robot will quickly change the car's battery for a fully charged one that will last the rest of the trip.

Better Place's switching stations are an attempt to work around the limited battery capacity that is the biggest technological barrier to wider use of electric cars. Even the newest models cannot match the range of a conventional car with a full gas tank.

Better Place's solution is to build networks encompassing charge points that drivers can use to recharge while they're parked, and switching stations they can turn to if that charge runs out. The company's robots can swap a depleted battery for a fresh one in less than four minutes, about the time it takes to fill a conventional car with gas. Recharging a car like Pearl's at a charge point takes up to eight hours.

In January the company will open networks in Israel and Denmark to serve hundreds of drivers. Renault has agreed to supply 100,000 of its cars for Better Place customers in those two countries by 2015. Users sign a service contract, similar to a cell-phone subscription, under which they get access to the switching stations and Better Place retains ownership of the batteries, an arrangement that reduces the cost of buying an electric car. A third network will launch in Australia in the second half of next year. tr

GIL LAVI

2

3

1. Each Better Place charge point is connected wirelessly to a national operations center that tracks the energy needs of all batteries in the network. The rate of charge can be varied to balance demand on the electricity grid with the need to ensure that each battery is prepared for a car's next journey. When possible, charge points draw the most electricity during off-peak hours, soaking up excess capacity when demand is low.

2. A display to the left of the speedometer, similar to a gas gauge, shows the battery's remaining charge. The car's computer continuously monitors the charge level and the distance to the planned destination. If the battery doesn't have enough charge to make it, the driver is notified and offered a route to the most convenient switching station. Better Place's Israeli network is designed so that one is never more than 25 miles away.

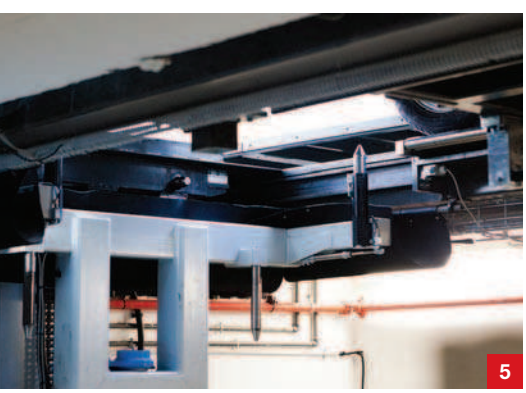
3. A battery switching station looks much like a car wash. Hydraulic clamps take hold of the wheels and maneuver the vehicle into position over the underground machinery that will change the battery. Screens inside the car and on the wall of the station guide the driver. As the car approaches the station, it identifies itself over a wireless link so that the correct type of battery can be moved into place.

4. Beneath the switching station, a series of industrial robots handle a stock of 16 batteries, one of which can be seen at the lower right in this image. To maintain their capacity, the batteries are kept cool as they are recharged. Each battery has a maximum capacity of 22 kilowatt-hours, yielding a driving range of approximately 100 miles in normal conditions. Better Place calculates that this range is sufficient for the majority of regular journeys, with the switching stations on hand for the rest.

5. The underside of the car is automatically washed and dried, and then a well opens beneath the car so the battery switcher can go to work.

6. A robot reaches up to release and remove the car's battery, which sits between the rear passenger seat and the trunk. That battery is lowered into a rack, where it will be recharged. The robot then lifts a fully charged replacement battery into the vacant space. After the opening closes, the clamps release the car. The entire process takes three minutes and 40 seconds.

4



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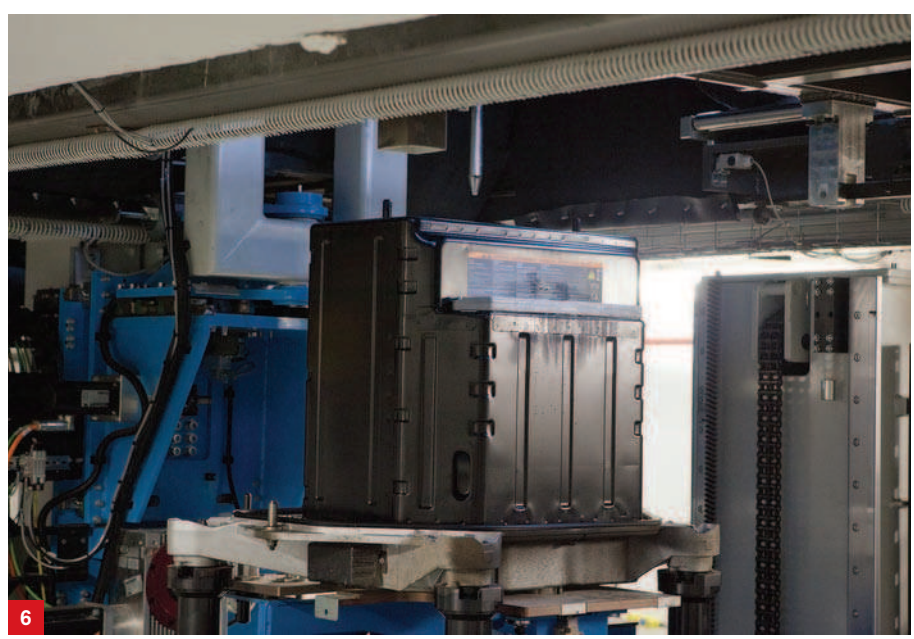

6

GIL LAVI

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— *C. from Colorado*

★★★★★

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— *W. from Nebraska*

★★★★★

"WOW! It is an eye-catcher!"
— *A. from Florida*

★★★★★

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— *C.B. from Maine*

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INFORMATION TECHNOLOGY

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A quantum computer with the same basic design as a conventional one

SOURCE: "IMPLEMENTING THE QUANTUM VON NEUMANN ARCHITECTURE WITH SUPERCONDUCTING CIRCUITS"
Matteo Mariantoni et al.
Science 334: 61-65

RESULTS: For the first time, a computer processor that uses the quirks of quantum physics to handle information has been teamed up with a memory device that can store data encoded into quantum states. The memory behaves like the RAM, or random access memory, of a conventional computer. Matteo Mariantoni and collaborators at the University of California, Santa Barbara, built the system and used it to run two different algorithms. One can allow a quantum computer to crack encryptions that are practically impossible for a conventional computer to break; the other is a kind of mathematical building block that can be used to fix errors in quantum computations, called quantum error correction.

WHY IT MATTERS: Quantum computers have the potential to be much more powerful than conventional ones. The components inside the computers we use today represent all data using combinations of *0*s and *1*s, but each digital bit in a quantum computer can also take on both states at the same time in a phenomenon called superposition. The UCSB design is the first to combine processor and memory components in an architecture known as a von Neumann design, marking a milestone that conventional computing first passed in the late 1940s. It made computers easier to reprogram and enabled them to run more complex algorithms. The quantum equivalent of this achievement could have similar effects.

METHODS: The UCSB computer's circuits are made from metals that become superconducting when cooled almost to absolute zero, activating the quantum effects that make them useful. The computer's processor consists of two or three "qubits," each able to represent data as a *1*, a *0*, or both at once. The qubits can interact to process data and are also connected to memory elements that can store a quantum value for later use. Unlike previous quantum-computing components, this type can be made using standard chip manufacturing techniques.

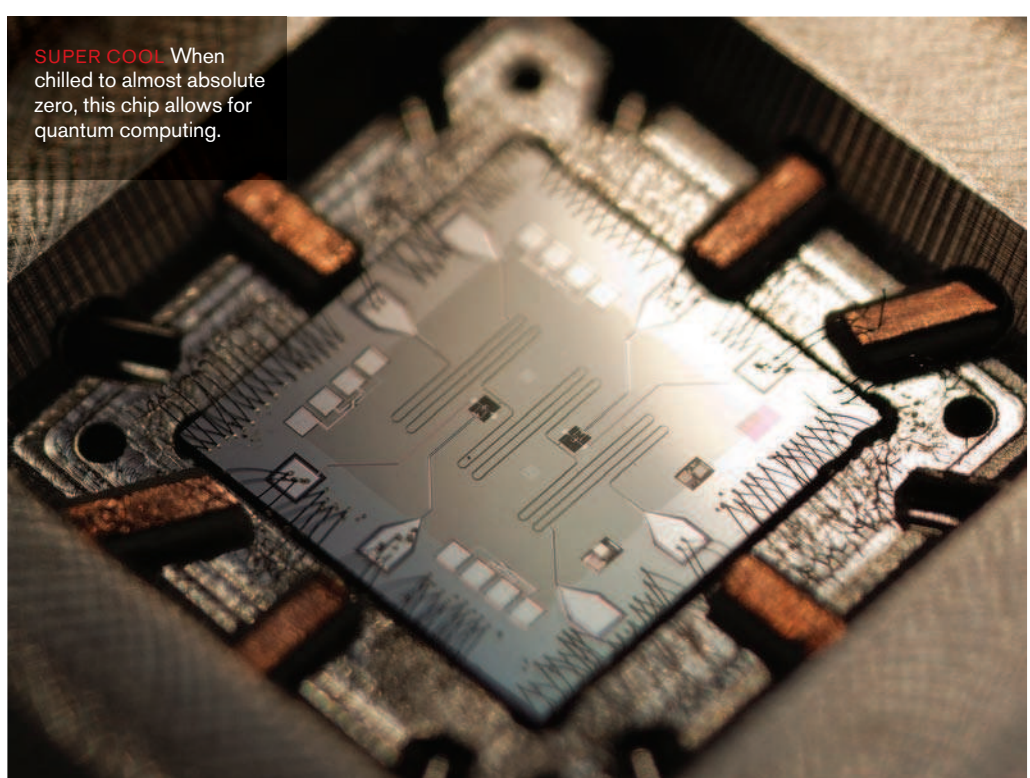
NEXT STEPS: The researchers are working to try out more algorithms on the new computer design and considering how they might scale it up to include more processing or memory power.

Planning by Taxi

GPS data gleaned from taxicabs can identify flaws in transportation infrastructure

SOURCE: "URBAN COMPUTING WITH TAXICABS"
Yu Zheng et al.
13th ACM International Conference on Ubiquitous Computing, Beijing, China, September 17–21, 2011

RESULTS: Scientists at Microsoft Research Asia have used GPS data from more than 33,000 taxicabs in Beijing to pinpoint problem areas in the city's transportation network.



SUPER COOL When chilled to almost absolute zero, this chip allows for quantum computing.

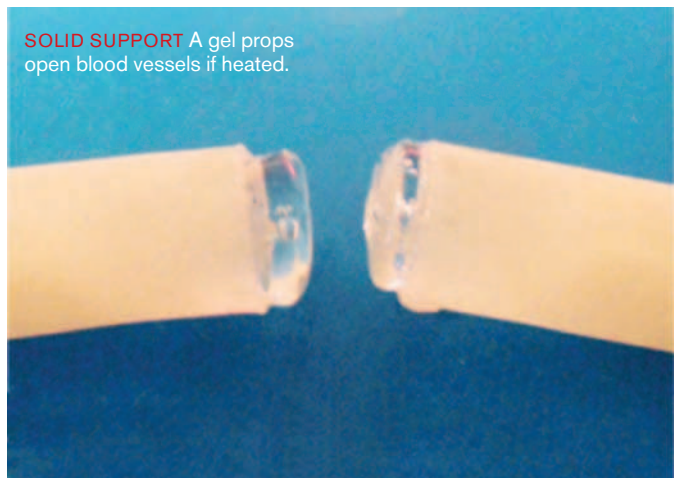
ERIK LUCERO

The researchers analyzed data collected in 2009 and 2010 to find areas where roads and subway lines were overloaded. Then they evaluated the results by examining how their calculations changed as Beijing's transportation network evolved during the two-year period they monitored. They found that where city planners added connections between regions that algorithms had identified as overloaded, conditions did improve. Where flaws were identified but not fixed, traffic got no better.

WHY IT MATTERS: Big cities worldwide are struggling to keep their infrastructure in line with the needs of their populations. A way to automatically detect problems with transit systems could be valuable to overburdened city planners.

METHODS: The researchers used data from the taxicabs to identify congestion-prone transition points between regions of the city. Further analysis helped them predict exactly where new streets or subway lines might relieve the pressure. Analyzing complex traffic patterns this accurately would be impossible without information on the large scale yielded by the GPS data.

NEXT STEPS: The researchers hope to make their predictions more accurate by considering more types of data, such as information about geographical features. They might also look more closely at the congestion patterns that develop around specific occasions, such as sporting events. The researchers say their method could be applied to any major city that has a large taxi fleet, including Buenos Aires and New York City.



SOLID SUPPORT A gel props open blood vessels if heated.

BIOMEDICINE

Gluing Blood Vessels

A novel material could eliminate the need for sutures

SOURCE: "VASCULAR ANASTOMOSIS USING CONTROLLED PHASE TRANSITIONS IN POLOXAMER GELS"
Geoffrey C. Gurtner et al.
Nature Medicine 17: 1147–1152

RESULTS: Researchers developed a heat-sensitive polymer that allows surgeons to prop open a severed blood vessel so they can glue its ends together, avoiding the need for sutures. In tests in rats, the procedure worked in vessels smaller than half a millimeter in diameter, where traditional sutures failed. The technique was also faster than sewing and resulted in less scarring and inflammation.

WHY IT MATTERS: The gel could aid in delicate surgeries and make it easier to repair blood vessels that are small or difficult to access, particularly in infants. It may also prove useful for minimally invasive surgeries, in which surgeons have little room to maneuver and suturing is particularly difficult.

METHODS: The researchers altered the chemical properties of a medically approved polymer so that it is liquid at body temperature but solidifies at a few degrees higher. They heated the area around severed vessels in rats and used the solid polymer to hold the ends open. The open ends were then reconnected with surgical glue. When the area cooled back to body temperature, the polymer melted and dissolved into the bloodstream.

NEXT STEPS: The researchers are trying to improve the glue used to seal the two ends of the blood vessel. They aim to test the technology in patients next year.

Reversing Aging in the Brain

Young blood stimulates cell growth in old mice

SOURCE: "THE AGEING SYSTEMIC MILIEU NEGATIVELY REGULATES NEUROGENESIS AND COGNITIVE FUNCTION"
Tony Wyss-Coray et al.
Nature 477: 90–94

RESULTS: Blood from young mice can relieve inflammation in the brains of old mice while improving memory, promoting increased neural activity, and stimulating the growth of new brain cells. Blood from old mice has the reverse effect on the brains of younger mice. Researchers linked the brain aging effect to a specific chemical in blood that increases with age and has previously been associated with allergies and asthma.

WHY IT MATTERS: The findings suggest that brain aging is in part caused by molecules in the blood and not by a process intrinsic to brain cells themselves. They also suggest the possibility of slowing age-related decline by blocking the chemical. In addition, monitoring the blood for chemicals linked to brain aging might be useful in assessing brain health, since brain tissue is difficult to test directly.

METHODS: The researchers surgically linked two mice—one of them old and one young—so that they shared a circulatory system. They monitored the animals' brains and screened 60 molecules found in blood to identify those that affect the brain.

NEXT STEPS: The researchers continue to search for blood-borne factors that influence brain aging.

MATERIALS

Energy-Harvesting Displays

Solar cells inside displays could make for self-charging cell phones

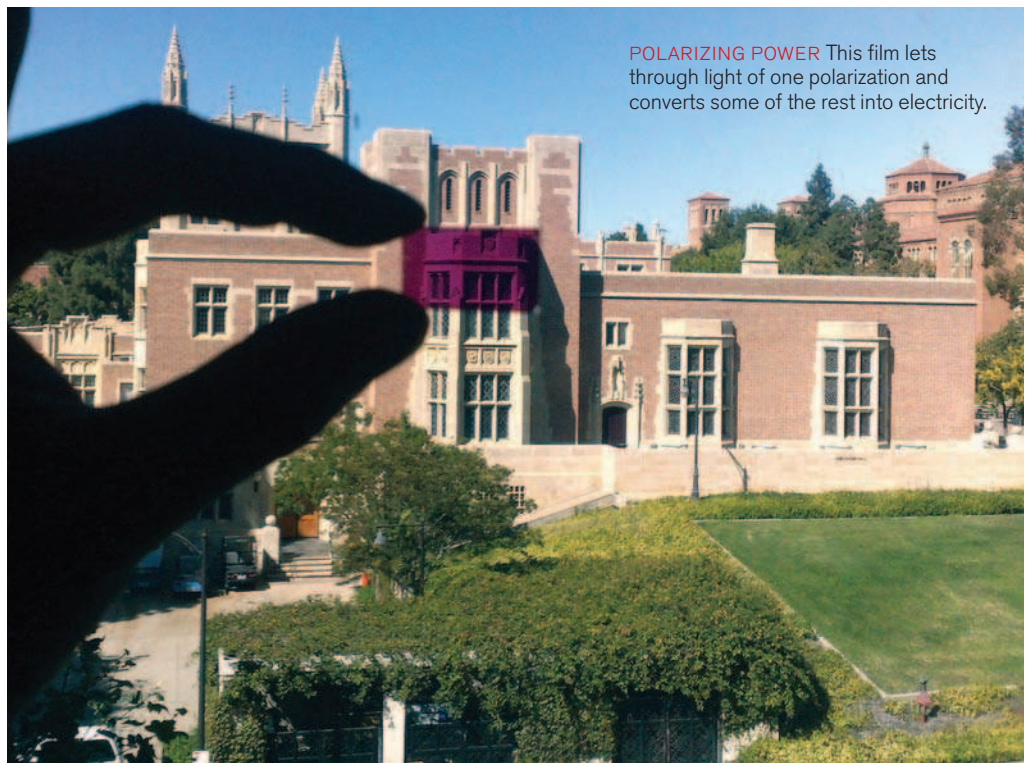
SOURCE: "POLARIZING ORGANIC PHOTOVOLTAICS"
Yang Yang et al.
Advanced Materials online, August 9, 2011

RESULTS: Researchers have made an optical filter that can double as a solar cell, converting light into electricity. The new filter, a type of polarizer, works just as well as the polarizers normally used in liquid-crystal displays. But it can convert 4 percent of the light wasted by ordinary polarizers back into electricity. It can also scavenge energy from ambient light and sunlight.

WHY IT MATTERS: More than 90 percent of the displays sold this year to serve as screens for cell phones, tablet computers, televisions, and other electronic devices will be liquid-crystal displays. These displays are inexpensive to make, but they have dismal energy efficiency: only about 5 percent of the light produced makes it to the image that the viewer sees. Polarizers, which filter out light coming from different angles to make it compatible with the liquid-crystal shutters found in these displays, are the most wasteful component. A lot of power could be saved by photovoltaic filters that convert otherwise wasted light into electricity to power the display.

METHODS: Researchers at the University of California, Los Angeles, started by making a small, thin sheet of the material most commonly used as the light-absorbing layer in plastic solar cells. They repeatedly rubbed the sheet with a cloth to comb the polymer molecules into the same orientation. With its molecules thus aligned, the film can act as a polarizing filter, letting through half the light and absorbing the other half. The researchers then added the other layers necessary to make a solar cell, including a charge collector to get electrical current out of the device.

NEXT STEPS: The researchers hope to identify materials that can increase the efficiency of the photovoltaic filter. They are currently in discussions with device manufacturers about commercialization.



POLARIZING POWER This film lets through light of one polarization and converts some of the rest into electricity.

UCLA

Practical Optical Circuits

A silicon waveguide overcomes a fundamental barrier to optical computing

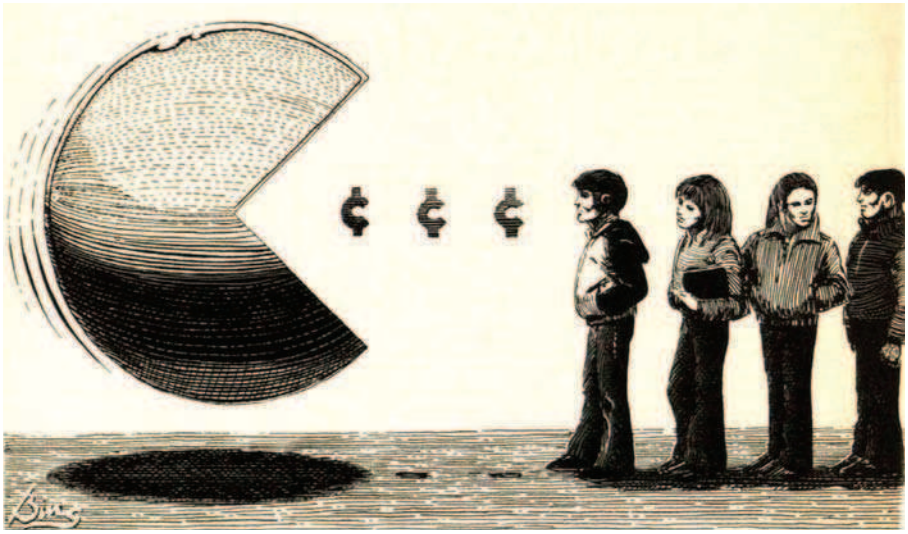
SOURCE: "NONRECIPROCAL LIGHT PROPAGATION IN A SILICON PHOTONIC CIRCUIT"
Axel Scherer et al.
Science 333: 729–733

RESULTS: A silicon waveguide developed by researchers in California causes light to behave differently depending on the direction in which it's moving. Light is able to travel freely in one direction down the waveguide but is bent as it travels in the opposite direction.

WHY IT MATTERS: Physicists have been wrestling with the unruly behavior of light in silicon for a long time: it has a tendency to scatter, even reflecting backward. Controlling this behavior has been one of the biggest challenges facing researchers trying to develop optical circuits, which promise to be faster and more energy efficient than the electrical circuits used in today's computer chips. Researchers at Caltech and the University of California, San Diego, developed the directional waveguide using the same equipment and the same material—silicon—that's used to make today's computer chips.

METHODS: Using methods that are already common in the semiconductor industry, the researchers fabricated a long, narrow strip of silicon about 800 nanometers wide, with metal spots along the side like bumpers. Then they performed a series of tests to characterize the way light moved through this waveguide.

NEXT STEPS: Changing the behavior of light moving in a particular direction may be the most difficult challenge in solving the problem of light scattering in silicon circuits, but it is only the first step. The researchers are now building on this work to engineer a device called an optical isolator, which won't just bend light traveling in one direction but bring it to a halt. This isolator will then be tested in optical circuits. tr



The Dubious Perils of Pac-Man

One writer bristled at the idea that video games might be corrupting her daughters.

By TIMOTHY MAHER

In 1982, Surgeon General C. Everett Koop warned an audience of public-health workers about the three top culprits for family violence: economic hardship, TV, and video games. "All you have to do," Koop said, "is see a youngster playing a video game and watch his behavior as exhibited by body language or outright attacks on components of the game or the television screen to understand just how deep is the connection."

Koop's words prompted a rebuttal—titled "Will Pac-Man Consume Our Nation's Youth?"—in the June 1983 issue of *TR*. Carolyn Meinel, a computing enthusiast and author of a book on hacking, said Koop might have had a point about TV and poverty, but he was dead wrong on video games.

Koop's warnings on the hazards of explicit TV violence are documented by extensive research done during the 1960s and 1970s ... However, there is scant evidence to support Koop's assertions on the hazards of video games. Unlike TV, such games are typically highly symbolic with no actual portrayal of blood and guts. Like chess, the figures zapping one another on the video screen are stylistic images that bear little resemblance to human forms.

Of course, all those human forms that didn't exist in Pac-Man or Defender now exist in graphic, bloody detail in games like Gears of War and Mortal Kombat. But experts still debate whether that imagery is a harmless (if slightly depraved) emotional outlet or something that leads to aggression in the real world. (The same goes for the effects of TV violence, despite Meinel's assertion that the issue was settled.)

Meinel's feeling was that video games were here to stay whether we liked them or not—so we might as well use them as a tool for good.

I first introduced my kids to computer games back in 1974 ... The kids learned to add fractions by mixing chemicals to grow monsters on an orange phosphor screen ... I beam smugly when the neighborhood toddlers come over and my three-year-old Ginny runs to the computer and loads a game of Breakout for them to play. Valerie, nearly five now, uses the screen editor to work on spelling.

Meinel saw the outrage against video games on a continuum of outrage against any youth sensation and contended that the real target was the kids themselves.

In an attempt to reverse this trend, state legislators in New York introduced a bill last year to ban the banning of video games—to the applause of chronic adolescents such as me ... Why doesn't the surgeon general warn us that the kid who forks a queen with a rook today will be holding the principal and the playground monitor hostage with a zip gun tomorrow?

Meinel, now a freelance journalist living in New Mexico, says her daughters, who are in their 30s and 40s, show no detrimental effects from the activities of their youth. "None of them has a police record," she says.

She's aware that games have gotten much more graphic and violent in the nearly three decades since she wrote the article, but she laments the fact that people are still quibbling over their effects (in June of this year, for instance, the U.S. Supreme Court struck down a California law banning the sale of violent games to children). While there have been a fair number of studies on the topic, none have been definitive enough to settle the debate among policy makers and social scientists.

"What if it turned out that graphically violent computer games provided a safe release so that I don't have to worry—as a 65-year-old woman walking around in the middle of nowhere on a hike or something—about some crazed guy jumping out of a bush with a chain saw?" she says. "What if that were the outcome, that these games prevent violence? It's worth finding out." tr

TIMOTHY MAHER IS *TR*'S ASSISTANT MANAGING EDITOR.

CHRISTOPHER BING

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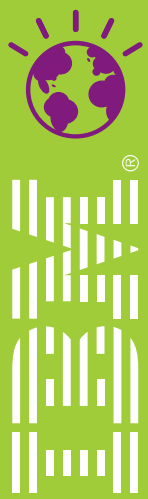

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